CARBONIFEROUS STRATIGRAPHY OF THE LEONARD RANCH

AREA, SAN SABA COUNTY, TEXAS

APPROVED:

W C Bell

Robert L. Folk

Ernest Lundelius Jr.

CARBONIFEROUS STRATIGRAPHY OF THE LEONARD RANCH AREA, SAN SABA COUNTY, TEXAS

by

JOSH WINTERS ODEN, B.S.

THESIS

Presented to the Faculty of the Graduate School of

The University of Texas in Partial Fulfillment

of the Requirements

For the Degree of

Master of Arts

THE UNIVERSITY OF TEXAS

AUGUST, 1958

CARBONIFEROUS STRATIGRAPHY OF THE LEONARD RANCH AREA, SAN SABA COUNTY, TEXAS

by

Josh Winters Oden

ABSTRACT

Mississippian and Pennsylvanian strata of the Leonard Ranch area do not correlate nicely with the Mid-Continent standard section, nor can they be forced into current published classifications. Study of the field relationships, petrography, and paleontology has shown that some lithic units are discontinuous but that the Marble Falls formation can be usefully subdivided into the following members: Lower limestone, Middle limestone and shale, and Upper limestone. Physical and faunal evidence do not support the interpretation of an unconformity between the Barnett and Marble Falls formations, nor does the formation boundary coincide with the systemic boundary.

Twenty-nine species of conodonts, twenty-three species of brachiopods, seven gastropods, two cephalopods, and two corals are described from the Chappel, Barnett, Marble Falls, and Smithwick formations. Possibilities for zonation are presented.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

Figures

Fossil Plates

Plates

CARBONIFEROUS STRATIGRAPHY OF THE LEONARD RANCH AREA, SAN SABA COUNTY, TEXAS

INTRODUCTION

Devonian, Mississippian, and Lower Pennsylvanian strata of central Texas are not easily interpreted stratigraphically, but the unnecessarily confused situation described by existing literature derives primarily from a lack of factual information of the sort that can be obtained by intensive study of the strata. They crop out primarily in a discontinuous circular pattern on a domed structure (Llano Uplift) that exposes at its crest Precambrian and lower Paleozoic rocks. Many exposures are in widely separated fault blocks, and lateral lithic gradational changes cannot be traced from outcrop to outcrop. This paper presents the results of a stratigraphic study based on field relationships, petrography, and paleontology of the Leonard Ranch area in San Saba County.

LOCATION AND ACCESSIBILITY

The area investigated is in western San Saba County (Fig. 1), approximately 12 miles south of Richland Springs, and 15 miles southwest of San Saba. Comprising approximately 30 square miles, it lies north of Brady Creek and the San Saba River, south of parallel $31^{\circ}12'$ and east of meridian $99^{\circ}01'$.

The area can be entered from either San Saba or Richland Springs by all-weather roads, but during wet weather entrance should be made from Richland Springs because of low-water crossings on the San Saba River. Many of the intermittent streams in the area become impassable almost instantaneously during sudden rains. Travel by vehicle within the

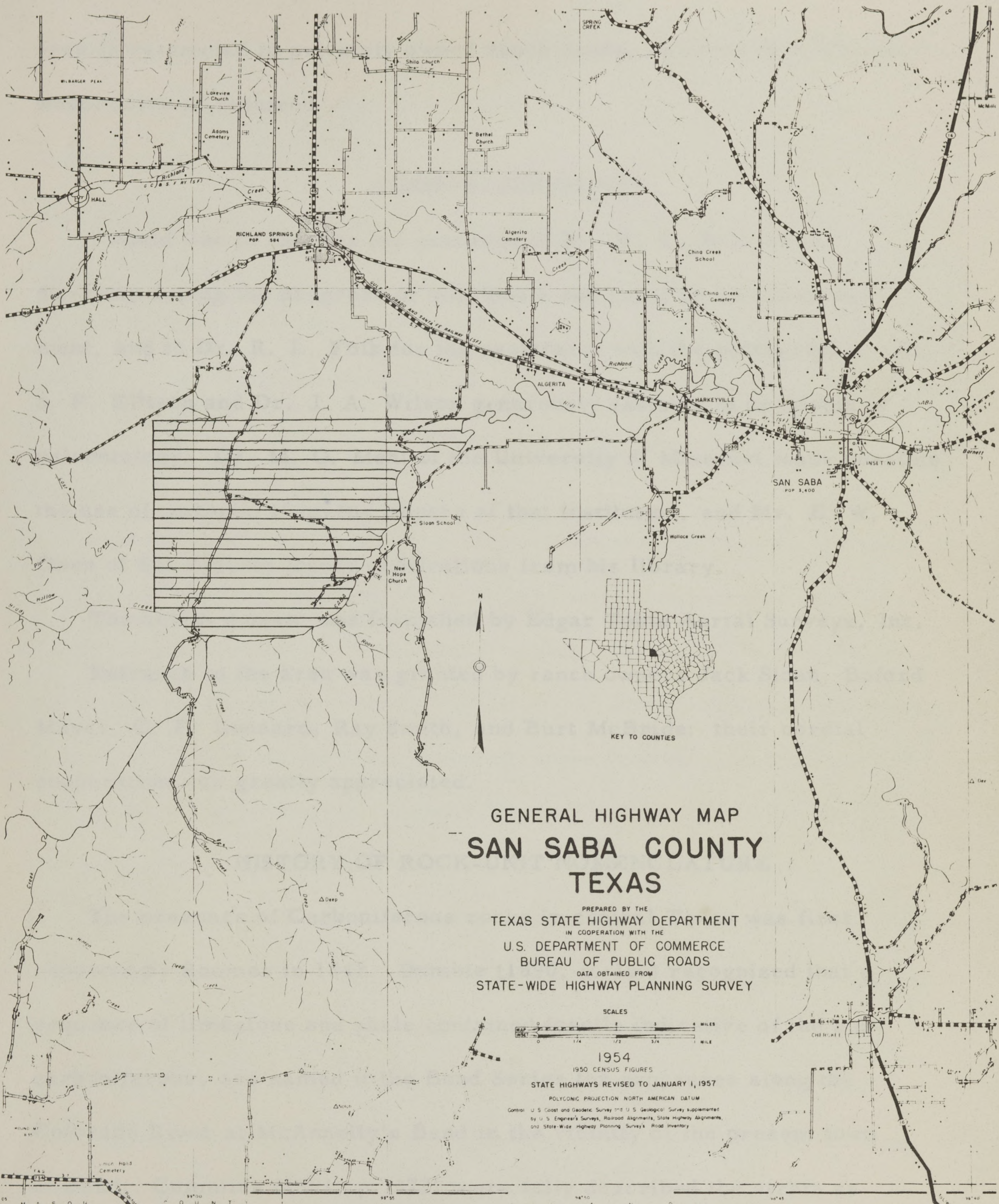


Fig. 1. Location map of Leonard Ranch Area.

area is restricted to privately owned ranch roads, on some of which four-wheel drive is required.

ACKNOWLEDGMENTS

I would like to express my gratitude to Dr. W. C. Bell for his direction during the progress of this thesis and prior to its commencement, and to Dr. R. L. Folk for his assistance with the petrography. Dr. S. P. Ellison and Dr. J. A. Wilson generously assisted in problems of paleontology. Dr. M. G. Mehl of the University of Missouri made possible the use of material from the library of that institution, and Mr. E. W. Owen of San Antonio loaned publications from his library.

The aerial mosaic was furnished by Edgar Tobin Aerial Surveys, Inc.

Entrance to the area was granted by ranch owners Jack Sloan, Buford Mayes, O. P. Leonard, Ray Smith, and Burt McBride; their cordial cooperation was greatly appreciated.

HISTORY OF ROCK-UNIT NOMENCLATURE

The presence of Carboniferous rocks in central Texas was first reported by Roemer in 1847. Dumble (1890, p. lxv) recognized that a sequence of limestone and shale contained fossils indicative of the Subcarboniferous, and named it the Bend Series for exposures along the Colorado River at McAnnelly's Bend in the vicinity of the present town of Bend. Cummins (1891, p. 372) more fully described the strata as composed of dark blue and black limestone and shale overlain unconformably by the Strawn sandstone.

R. T. Hill (1889, p. 289) named the Marble Falls or "Encrinital" limestone for exposures along the Colorado River near Marble Falls, Burnet County, and Paige (1912, p. 8) named the overlying Smithwick shale for exposures a few miles downstream near the old town of Smithwick. Udden, Böse, and Baker (1916, p. 44) reported the presence of a shale beneath the Marble Falls and included it in the Bend Group, as did Girty (1919, p. 71), Girty and Moore (1919, p. 419), and Plummer and Moore (1922, p. 24), who named it the Barnett shale from a locality at Barnett Springs, San Saba County.

Roundy, Girty, and Goldman (1926) described a "Boone" limestone beneath the Barnett shale. Sellards (1933) named this limestone the Chappel formation and redefined the overlying units as the Barnett, Marble Falls, and Smithwick formations, the latter two comprising the Bend Group. Bullard and Plummer (1939) proposed the name Ives conglomerate for a chert breccia that locally occurs beneath the Chappel. The Ives was redefined as the Ives breccia by Cloud and Barnes (1948, p. 46).

Terminology of the Chappel and Barnett formations has been relatively unchanged since 1933 except that Cloud and Barnes (1948, p. 52) designated as Barnett a "limesand" unit in the southwestern part of the uplift.

Attempts to subdivide the Marble Falls can be attributed largely to F. B. Plummer and M. G. Cheney. Cheney (1940, p. 83) named the Big Saline formation for exposures in Kimble County. Division of the Big Saline into members was based on subsurface information, and member names were applied to the Big Saline type locality.

Plummer's subdivisions (1945, 1947, 1950) are based on a combination of stratigraphic interval and lithology, with a strong accent on paleontology. His first attempt to subdivide the Marble Falls (1945, p. 73) is as follows:

Series	Formation	Members	Coral zones
Bend	Smithwick		Cumminsia aplata
	Upper Marble Falls	Lemons Bluff	Neokoninckophyllum gracile
		Big Saline	Rodophyllum texanum
Morrow	Lower Marble Falls	Sloan	Stereocorypha annectans

This classification incorporates the Big Saline, redefined as a group by Cheney in 1945 (1. 125), but Plummer treated it as a member of the Upper Marble Falls formation.

Plummer's next classification (1947, 1. 193) takes account of a vague structural feature, Cavern Ridge, that supposedly prevented continuous deposition across the uplift. The flexible Big Saline, again ranked as a formation, incorporated all Marble Falls strata west of Cavern Ridge.

Group	Formation	East of Cavern Ridge	West of Cavern Ridge
Bend (Atoka)	Smithwick	Siltstone facies Shale facies	Absent
	Big Saline	Brister	Soldiers
		Lemons Bluff	Lemons Bluff
		Aylor	Brook Ranch
		Gibbons	Gibbons
Morrow (upper)	Sloan	Present	Absent

His last classification (1950, p. 47), published posthumously, is essentially the same as that of 1947. Bend and Morrow are treated as Series, and the Marble Falls group consists of the Sloan and Big Saline formations. Members were changed only by the addition of descriptive words; the Brister and Aylor members were changed to Brister Bluff and Aylor Bluff, Soldiers was changed to Soldiers Hole, and the Gibbons was changed to the Gibbons conglomerate.

FIELD PROCEDURES

Mapping was started in June, 1956. Aerial photographs with a scale 1:7200 were used in the field; results were transferred to an aerial mosaic, scale 1:24000. Areas of good exposure were mapped by a combination of close traverse and walking out marker beds. In areas of poor exposure, discernable beds were traced. Where exposures were extremely poor because of low relief and excessive alluvium, float was used to approximate unit boundaries. Photographically evident structural features were first mapped on the photography and later corrected by field observation. Units mapped are strictly field units, and no formal classification is proposed or intended (Pl. 1, in pocket).

Sections were measured with a five foot staff and a Brunton pocket transit. Stratigraphic intervals were marked with a horizontal bar of yellow paint and numbered every 25 feet above the base. Rock specimens for petrographic study were collected every five feet in uniform material; any distinctive lithic change was also collected. Fossils were collected from measured sections when possible, but because exposures best suited for measuring yielded poor collections, many localities are lateral to measured sections; in all instances fossils were collected from comparable rock types.

Of the ten sections recorded in Appendix A and on Plate 1 (in pocket), only eight are shown on the panel diagram (Pl. 2, in pocket). Challenge Mill and Leonard Tank sections were omitted from the panel diagram because they are entirely Barnett. The Burr Tank section is westernmost, approximately 6000 feet southwest of Hackberry Mill; Challenge Mill North and East sections are in the large central fault block, north and east of Challenge Mill. The Pecan Grove Creek section is easternmost, north of Leonard Tank. The Post Oak Creek section, west of Lemons Camp in the southern part of the area, lies between Ink Hole and Bluff Creek sections. The latter two sections are not in the mapped area but were utilized because of the control offered by their close proximity to my Post Oak Creek section. The Ink Hole section is approximately 1000 feet due west of the base of the Post Oak Creek section, and the Bluff Creek section is directly across the San Saba River from Lemons Camp, about 1500 feet due east of the base of the Post Oak Creek section.

TOPOGRAPHY, DRAINAGE, AND VEGETATION

Areas not influenced by the San Saba River drainage are characterized by low relief whose pattern is determined by faults (Pl. 1, in pocket). Where strata dip into a single fault, cuesta-like outcrops are formed.

Compensatory flattening of dips by opposing normal faults decrease the amount of relief across the fault blocks. The undisturbed ends of the fault blocks form slopes that are generally good outcrops. Relief within a single fault block is minor because of internal drainage and compensatory effect of opposing normal faults.

Drainage toward the San Saba River characterizes the southern and eastern parts of the area. The central, western, and northern parts drain northward toward Richland Springs. The opposition of these drainage directions contributes to the very low relief in the central fault block.

Vegetation is controlled by a combination of topography and rock type. Areas that have accumulated sufficient soil cover have a predominance of varieties of oak. The Barnett shale, the Lower Marble Falls, and slopes subject to rapid erosion are covered by dense growth of cedar, catclaw, and sparse post oak. Mesquite frequently indicates underlying shale, but also occurs on soil-covered Ellenburger.

STRATIGRAPHY

ORDOVICIAN SYSTEM

Ellenburger Group

Limestone and dolomite of the Ellenburger group (Cloud and Barnes, 1948) were not differentiated during this study. These rocks are microcrystalline to sublithographic carbonates that are white, light gray, and light pink and brown on a fresh surface and light to medium gray when weathered. Chert is commonly present in nodules and thin lenses. This chert is lighter in color than any in the Marble Falls. Fine and medium well rounded and angular quartz sand grains are sparsely distributed throughout the Ellenburger in the Leonard Ranch area. Because of its lighter color and the presence of a well developed joint system expressed by vegetation, the Ellenburger is easily mapped as a single unit on photographs.

MISSISSIPPIAN SYSTEM

Houy Formation

The Houy was defined by Cloud, Barnes, and Hass (1957) as a transitional Devonian and Mississippian formation composed of three members. Only one, the Ives breccia, is present in this area.

Ives Member

Lithology. - Commonly referred to as "breccia", the Ives consists of angular red and dark brown chert fragments and sand grains set in a siliceous matrix. The chert is thought to have been derived from underlying Ellenburger, the difference in color being attributed to oxidation. Cementation has so thoroughly welded the chert particles together that fractures cross chert and cement indiscriminantly.

Areal extent and thickness. - Float identified as Ives was found at only two localities, although five exposures of the overlying Chappel were found. This suggests that the Ives is not everywhere present on the Ellenburger surface, and reportedly lies unconformably on the Ellenburger (Cloud and Barnes, 1948; Sellards, 1933; Plummer, 1950).

Chappel Formation

Originally named the Chappel formation by Sellards (1933), its designation was changed to Chappel limestone by Cloud and Barnes (1948, p. 49). Evidently Roundy (Roundy, Girty, and Goldman, 1926, p. 2) and Cloud and Barnes (1948, p. 49) described different but adjacent exposures about 2.5 miles airline distance from the San Saba courthouse on the San Saba-Chappel road. The outcrop described by Cloud and Barnes has since been covered by fill from a newer road cut that exposes Chappel (and Barnett) at the same locality.

Sellards (1933) and Plummer (1950) state that the Chappel lies unconformably on the Ellenburger, and Cloud and Barnes (1948, p. 49) state that there is an unconformity between the Chappel and Ives.

Lithology. - The Chappel in the Leonard Ranch area is an olive-gray to brownish-gray microcrystalline and fine-grained limestone that shows partial spotty recrystallization. Crinoid columnals are abundant and make up a large percentage of the rock locally. Acetic acid residues contain conodonts, limonite, pyrite, clay, a few authigenic quartz crystals, and medium quartz sand grains; rounded and frosted, and angular and clear grains are about equal in number.

Areal extent and thickness. - Of the five exposures of Chappel found in the area, none exceed four inches in thickness. Because of its thinness and the rapid weathering and slumping of the overlying shale, the limestone was not mappable and its areal relationship to the Ellenburger is not know. Quartz sand grains and clay were abundant in the insoluble residues and probably represent the only non-organic detrital material present; the relationship of the Chappel and Ives is not known.

Barnett Formation

Plummer and Moore (1922, p. 24) named the Barnett shale from an exposure near Barnett Springs, approximately five miles east of San Saba, but a much better section described by Cloud and Barnes (1948, p. 52) is exposed above the Chappel at its type locality in the new road cut.

Cloud and Barnes (1948, p. 51) and Sellards (1933) state that the Barnett overlies the Chappel unconformably.

Lithology. - The Barnett in the Leonard Ranch area consists of clayey, phosphatic shale that contains carbonate concretions near its base and thin discontinuous beds of limestone near its top. The shale is dark chocolate- to olive-brown, streaked with pastel shades of red, gray, yellow-brown, and green; weathering is rapid and produces a uniform olive-brown color.

The clay was determined to be illite by x-ray analysis. The shale contains conodonts, fish teeth, crinoid fragments, phosphatic material and rare grains of glauconite.

Limestone concretions from six inches to three feet in diameter occur near the base. They are composed of dark brown to brown-black, silty, microcrystalline limestone that yields a strong petroliferous odor when freshly broken, and they proved invaluable in locating the Barnett at poor exposures.

Uneven beds of dark brown to black, microcrystalline, bioclastic limestone characterize the upper five to ten feet of the Barnett. Of these several of the lower ones contain abundant sand-sized, very light brown, discoidal phosphate "pellets", aggregates of "pellets", fragments of goniatites, phosphate gastropod steinkerns, and phosphatic ooids embedded in microspar calcite. Occurring throughout the area, these beds are useful in locating or approximating the top of the Barnett.

Limestone and shale overlying the "pellet" beds are also distinctive in their high content of glauconite, some beds containing 60 per cent. Acetic acid residues contain conodonts, ostracods, fish teeth, unidentifiable fossil debris, glauconite, phosphatic "pellets", and a few well rounded and frosted quartz sand grains. The sand grains are restricted to the glauconitic interval near the top of the Barnett.

Areal extent and thickness. - The Barnett was not found at one locality, 2000 feet northwest of Hackberry Mill. Mapping in this area was based mainly on float material and none characteristic of the Barnett was found;

there is a covered interval between float of the Lower Marble Falls and Ellenburger. If this covered interval is actually Barnett, it is not over five feet in thickness. Elsewhere in the area the Barnett ranges in thickness from 35 feet in the Leonard Tank section to eight feet in the Sloan Ranch section (Pl. 2, in pocket).

Boundaries. - Both boundaries of the Barnett are relatively easy to map because rapid weathering and erosion of the shale creates a slope, usually mesquite covered, between the more resistant underlying Ellenburger and overlying Marble Falls. Separation of the Barnett and Chappel during mapping was less important than separation of the Barnett and Ellenburger.

Where exposed, the upper boundary of the Barnett is placed at the base of the lowest black, microcrystalline, cherty limestone that contains little or no bioclastic material, phosphate, and/or glauconite; above this boundary the limestone is distinctively thicker bedded. The basal bed of the Lower Marble Falls in all instances shows only a very small amount of fossil debris, glauconite, and phosphate so abundant in the upper Barnett.

The boundary between the Barnett and Marble Falls has been described as unconformable by Moore (1919, p. 234), Goldman (in Roundy, Girty, and Goldman, 1926, p. 53), and Girty (1919, p. 71). None of these men has claimed the presence of a basal conglomerate, but evidently have accepted the presence of phosphate and glauconite in lieu of it (Goldman, 1921; Sellards, 1933). Discussions of the unconformity omit any data pertaining to the existance or nature of the evidence for this unconformity and it has been expressed in terms of a paleontologic hiatus (Moore, et al., 1944, p. 706; Cheney, 1945, p. 125; Harlton, 1934, p. 1020; Moore and Thompson, 1949, p. 288).

Examination of the interval containing the Barnett-Marble Falls contact in all of my sections shows a gradation from shale to limestone, marked by a gradual increase in limestone, accompanied by a decrease in shale, in the upper Barnett. The fossil content of the upper Barnett shale and limestone is similar; the lithology of the limestone is very similar to that of the Lower Marble Falls. Thus, the significant difference between Barnett and Lower Marble Falls limestone is the sparsity of fossil material, phosphate, and glauconite in the latter. Two species each of brachiopods and conodonts (Fig. 8, 9) occur in both formations.

Mississippian-Pennsylvanian Boundary

Assignment of the Barnett to the Mississippian and the Marble Falls to the Pennsylvanian is purely arbitrary and conventional. The systemic boundary falls within the glauconitic interval of the Barnett if Polygnathodella cf. P. ouachitensis and Streptognathodus cf. S. elegantulus are accepted as solely Pennsylvanian species.

PENNSYLVANIAN SYSTEM

Marble Falls Formation

Hill (1889, p. 289) named the Marble Falls limestone, Paige (1912, p. 8) named the overlying Smithwick, and Plummer and Moore (1922, p. 24) named the underlying Barnett shale. The Marble Falls can be defined as the predominantly carbonate strata between the two shale formations. Units within the Marble Falls defined by Cheney (1940, 1945) and Plummer (1945, 1947, 1950) are not easily recognized or understood. Cheney divided his Big Saline group, exposed in Kimble County, into several formations, each formation having a "type locality" in a different well in north Texas. These formation names were then applied to the exposures in Kimble County. Plummer's divisions were identified in lithic terms at their type localities; lateral relationships were based on paleontology and stratigraphic interval with apparent disregard for several discontinuous rock types.

I was able to divide the Marble Falls in the Leonard Ranch area into three distinct units: a lower limestone, a middle limestone and shale, and an upper limestone. The boundaries between shale and limestone of the Lower, Middle and Upper Marble Falls generally are sharp, but at several localities are so gradational that they must be chosen arbitrarily. Where the boundaries are sharp, the contrasting rock-types commonly produce a topographic feature that is mappable in poorly exposed areas.

Lower Marble Falls Member

The Lower Marble Falls in the Leonard Ranch area includes the strata above the Barnett formation and below a light gray detrital limestone or a black to olive-brown shale. Plummer's Sloan formation (1950, p. 53) compares with part or all of my lower member, and he lists two fossil localities within my area as Sloan localities. Locality 205-T-92 (1950, p. 57) near the Nell Sloan ranch house, is in the shale overlying my lower member, and locality 205-T-98 (1950, p. 57) in Pecan Grove Creek probably is in limestone near the top of the Barnett. He illustrates two species, Caneyella wapanuckensis Girty (Pl. 8, fig. 3) and Nuculoceras barnettense Plummer and Scott (Pl. 8, fig. 16) as Barnett fossils, but they came from his "Sloan" locality 205-T-98. I have not recovered these species from the Lower Marble Falls.

Lithology. - These strata are composed of predominantly black to dark gray, microcrystalline limestone with thin interbedded dark shale lenses. The black color is attributed to organic matter; weathering produces a lighter gray color. Thin beds of allochemical, fine-grained limestone are distributed sparsely throughout the member. Beds range in thickness from less than one inch to three feet; the thicker beds exhibit very undulatory bedding.

Highly fractured black amoeboid chert nodules and lenses are common near the base. The nodules, six inches to one foot in diameter, are distinctive markers and provide recognizable float on poor exposures. The lenticular chert is locally abundant in the southern part of the area in the vicinity of Lemons Camp.

Within the carbonate strata are thin lenses of black hard fissile shale that grade laterally to shaly and very thin-bedded limestone, and contain concentrations of fossils, mainly productid brachiopods and bryozoa.

Petrographically, the dark limestone is microcrystalline to sublithographic with varying percentages of algal fragments, crinoid columnals, calcareous and siliceous spicules; foraminifers, mollusc fragments, brachiopod spines, microcrystalline silica, and grains of glauconite and phosphate are less abundant. The allochemical beds contain algal tubes and fragments, and carbonate intraclasts, 0.1 to 3.0 mm. in size, composed of a dark microcrystalline limestone. Much of the limestone contains allochemical particles, but there is much less bioclastic material than in the upper Barnett. Much of the matrix is microcrystalline, some of it recrystallized to microspar, but there is some sparry calcite present.

Acetic acid residues contain sponge spicules, rare fish teeth, ostracods, unidentifiable fossil debris, pyrite, silica, and rare grains of glauconite. Silicified fossils were obtained from local outcrops by etching in hydrochloric acid.

Areal extent and thickness. - This member is present over the entire area, but the thickest sections are along the San Saba River in the vicinity of Lemons Camp. Its thickness in the Ink Hole section, with a faulted base, is 75 feet. It thins northward to 30 feet in the Challenge Mill North section and eastward to only two feet in the Pecan Grove Creek section (Pl. 2, in pocket).

The upper boundary is placed at the base of an overlying shale or light gray bioclastic and oolitic limestone. Where the upper boundary is at the base of the shale there is another change of slope.

Middle Marble Falls Member

This member consists of shale and underlying bioclastic and oolitic limestone in the central part of my area, and of shale alone in the far western and northeastern parts of the area. The limestone was assigned to his Aylor Bluff lentil by Plummer (1950, p. 64-65) and a measured section is recorded that probably coincides with part of my Post Oak Creek section. The shale was not specifically accounted for by Plummer; apparently he regarded it as an eastward facies of the carbonate strata or as a part of the Lemons Bluff member. Writing about his Aylor Bluff lentil, Plummer stated (1950, p. 65)

> These more massive, more coarsely crystalline beds are apparently separated from the Sloan beds below by an unconformity.

Field and petrographic information indicates a stratigraphically short but marked gradation of rock-types between the Lower and Middle Marble Falls.

This member was designated Lower calcarenite by Bogardus (1957), but I shall refer to its two parts as Middle calcarenite and Middle shale.

Middle calcarenite

Lithology. - This unit (Fig. 3) is composed of two rock types: light gray to light brown allochemical limestone, which predominates, and pinkish-brown sublithographic algal limestone. The allochemical beds are thin; thickness is three to six inches and bedding is obscure and undulose. Outcrops appear massive because of consistent color and texture and negligible weathering between beds. Good exposures show strong crossbedding (Fig. 3) and apparent lensing, with apparent dips to the east as high as 20°. Light gray replacement chert nodules are common but not as abundant as in the Lower Marble Falls.

In the Post Oak Creek section the upper three feet (Fig. 4) is a light pinkish-brown, sublithographic limestone bed that contains angular and tabular masses of sparry calcite; they are thought to be recrystallized algal fragments. Weathering produces an uneven, nodular, and lumpy upper surface (Fig. 4) that shows circular stump-like colonies of Chaetetes. In the Bluff Creek section several similar beds occur in the top 25 feet of calcarenite.

At locality OD-11, in approximately the same stratigraphic position, small algal rosette-like bioherms are present. They are underlain by an 8-foot bed of limestone pebble conglomerate that may be an eastern extension of the calcarenite, but fault separation prevented certain correlation.

The allochemical constituents, 0.1 to 40 mm. in size, are usually in excess of 50 per cent in any thin section, and are contained in a microcrystalline and sparry calcite matrix indicating moderate winnowing. They are well rounded to angular intraclasts of dark brown microcrystalline limestone, 10 to 40 per cent, ooids, 2 to 5 per cent, and bioclastic material, 50 to 80 per cent. Some of the intraclasts are bent, suggesting transport while plastic. Algal tubes and fragments, and crinoid columnals are abundant; fish teeth, bone fragments, trilobite fragments, mollusc fragments and foraminifers are common. Much of the bioclastic material shows rounding that possibly resulted from transportation in a high energy environment. Sorting varies; the fine size allochems show better sorting and rounding. Several intraclasts up to three inches in length were found.

Figure 2. - Mottled beds in the Middle calcarenite at 78 feet in the Post Oak Creek section.

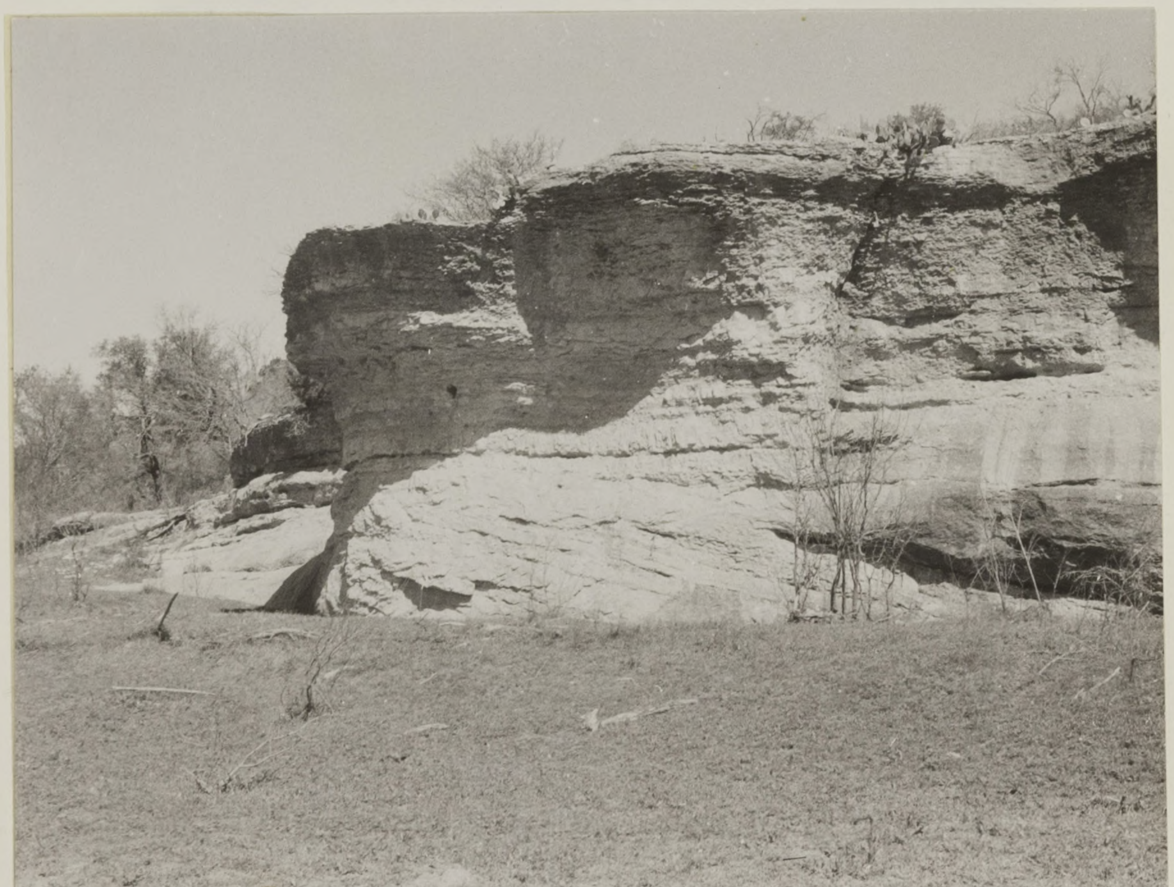


Figure 3. - Middle calcarenite of Post Oak Creek section showing eastward dipping cross-bedding.

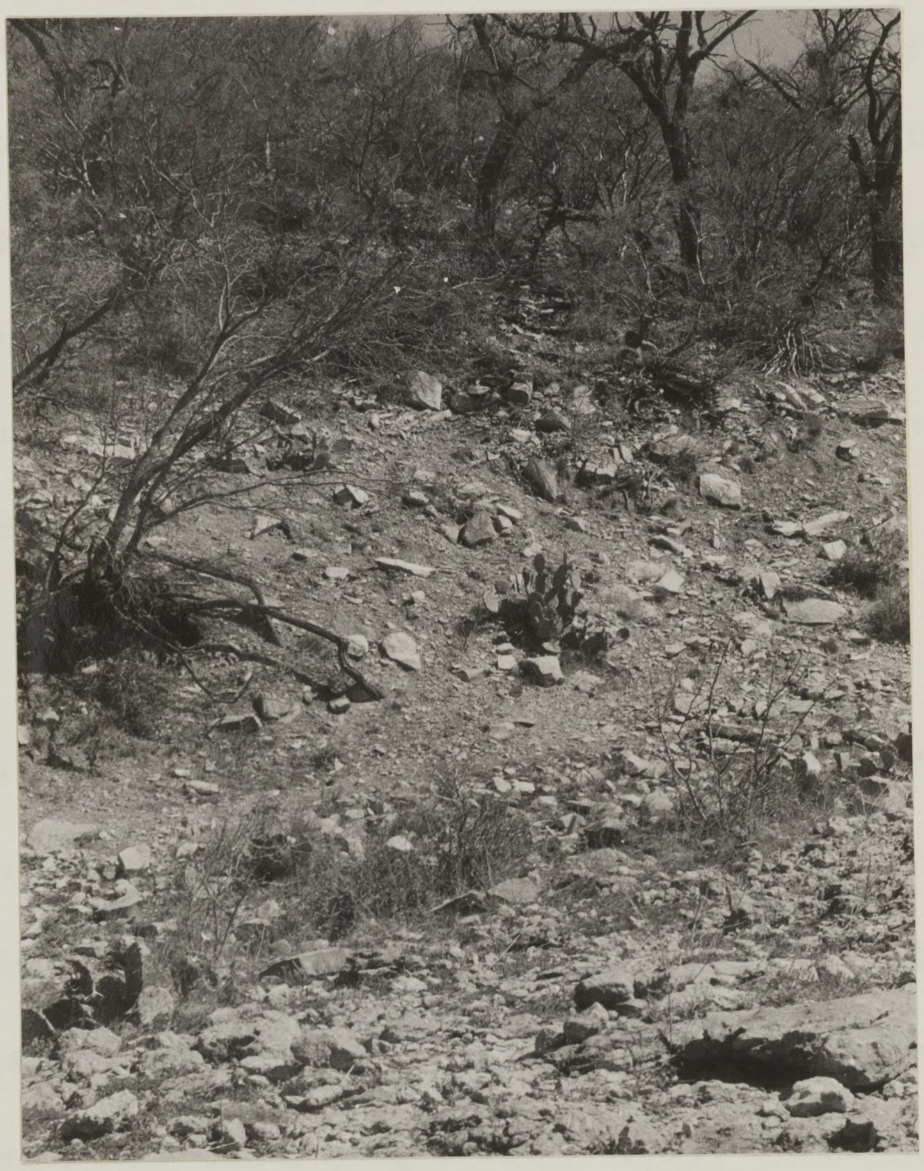


Figure 4. - Upper rubbly surface of Middle calcarenite overlain by Middle shale in Post Oak Creek section.

Areal extent and thickness. - The Middle calcarenite occurs as a lentil with a northward trend from the three southern sections, and is present in the central and northwestern sections. Maximum thickness of 50 feet is in the Bluff Creek section; the member thins westward to 13 feet in the Ink Hole section, and northward to 19 feet in the Challenge Mill North section. In the Sloan Ranch section 17 feet of strata is doubtfully assigned to this calcarenite because of similarity of color and bedding; allochemical material is not present in comparable quantities (Pl. 2, in pocket).

The upper boundary is sharp, where exposed, but is usually covered by slumping of the overlying shale.

Middle shale

This shale so resembles Smithwick shale that knowledge of stratigraphic position is essential to mapping.

Lithology. - In my area this shale (Fig. 4) is dark gray to blue black in fresh exposures. Weathering is rapid, producing a yellow-brown color and causing slumping onto underlying strata. Silty, black, microcrystalline limestone concretions were found near the middle of the shale at two localities. Weathered surfaces show many flattened brachiopods. Extremely local concentrations of crinoid columnals, corals, bryozoa, gastropods, pelecypods, brachiopods, and echinoid spines and plates occur at localities OD-2, OD-7, and OD-9.

Areal extent and thickness. - The Middle shale exists over the entire area and its thickness is related to the presence and thickness of the underlying calcarenite. Thickness ranges from 10 feet in the Challenge Mill North section, where 19 feet of calcarenite is present, to 69 feet in the Pecan Grove Creek section, where the calcarenite is absent (Pl. 2, in pocket).

The upper boundary is everywhere gradational through an interval that ranges from a few feet to 20 feet. Where the interval is large, the upper boundary is arbitrarily placed at the base of the first sequence of several limestone beds. The boundary usually is well exposed because of the more resistant overlying limestone.

Upper Marble Falls Member

This member overlies the Middle Marble Falls calcarenite and shale member, and underlies the Smithwick shale. Locally it is divisible into a lower siliceous and spiculitic limestone (Upper spiculite) unit and an overlying and interbedded calcarenite (Upper calcarenite) unit. Bogardus (1957) referred to these units respectively as Spiculite and Upper Calcarenite members of the Marble Falls formation.

Upper spiculite

The Upper spiculite (Fig. 6) is distinctive lithically and corresponds to Plummer's description (1950, p. 66) of the Lemons Bluff member of the Big Saline formation. He described a section (p. 67) on Turkey Roost Creek, about 1.5 miles southeast of Maxwell Crossing but the name evidently was derived from a bluff indicated on Plummer's (1950) geologic map as slightly downstream and across the San Saba River from Lemons

Camp.

Plummer's Lemons Bluff member, as used in the 1950 publication, was defined on stratigraphic interval away from its type locality, and its lower boundary is vaguely and inconsistently described. On his chart (p. 47) he shows the Gibbons as the basal conglomerate of the Big Saline formation, and states (p. 68)

> The stratigraphic relationships of the Lemons Bluff member with the beds below is unconformable. It thins by loss of its lower layers against bioherms of the Aylor Bluff member, is separated from the Aylor Bluff member in places by pellets, nodules, or by banded spherulites known as "algal biscuits" that are described elsewhere in this volume. It overlaps on the Sloan by a conglomerate of cobbles largely derived from the Aylor Bluff beds.

Plummer (1950, p. 62) lists 205-T-113, southwest of the Leonard Ranch headquarters as a Gibbons locality in my area. Because of the inadequate description, exact location of this conglomerate is not known. He states (p. 64) that the Gibbons conglomerate, one-half mile south of the Leonard Ranch headquarters, lies between the Barnett and Big Saline formations. I mapped a three foot limestone pebble conglomerate into the Upper spiculite of the Pecan Grove Creek section. If this conglomerate is accepted as Gibbons (described as a chert pebble conglomerate at its type locality) then the strata below, including the Middle shale must be Sloan, and the strata above must be Aylor Bluff. He described the Gibbons at this locality as a glauconitic, sandy, limestone conglomerate overlying the Barnett, but I found no conglomerate at this stratigraphic level.

A similar limestone pebble conglomerate, which I mentioned in connection with the Middle calcarenite, occurs southwest of Leonard Tank in the vicinity of locality OD-11, at the top of my Lower Marble Falls member. In Plummer's terminology, the strata below would be Sloan and the strata above, including my Middle shale, would be Aylor Bluff. Thus my Middle shale is Sloan at one locality and Aylor Bluff at another locality only two miles away.

Lithology. - Spiculitic limestone of the Upper spiculite weathers to a distinctive and consistent orange-brown to red-brown color. Weathering removes the carbonate, leaving a skin of rusty colored porous silica. Nodules, lumpy protuberances, and silicified fossils are common and add to the differance between weathered and fresh rock, which is light gray-brown to dark brown-black in color. Bedding is uniform and ranges in thickness from less than an inch to three feet. Thin shaly intervals are common.

Light gray to dark blue-gray speckled chert is present in thin nodules and beds. The nodules and beds are commonly fossiliferous, containing sponge spicules, fusulinids, and fossil debris, in contrast to the unfossiliferous nodules in the Lower Marble Falls.

Thin sections show the limestone to be microcrystalline, often recrystallized to microspar, with varying amounts of argillaceous material, organic matter, and microcrystalline silica distributed through the matrix. Spicules are abundant with foraminifers and fine unidentified fossil debris present in several beds. Silicified brachiopods and snails are exposed on weathered surfaces. Rare beds of allochemical limestone contain carbonate intraclasts smaller than 0.2 mm. in size. Some slides show slumping or flowage in the orientation of the grains of calcite.

Acetic acid residues were obtained from few beds because of the high silicification. In the residues obtained, porous masses of silica comprised up to 75 per cent; the remainder was mainly sponge spicules, fish teeth, bone fragments, and rare grains of glauconite and quartz sand.

The upper boundary of the Upper spiculite is placed either at the base of a black shale or of a light gray limestone that locally is so interbedded with the spiculite that division was not made.

Areal extent and thickness. - The Upper spiculite is present over the entire area and has its maximum thickness in the vicinity of Lemons Camp. This thickness, 100 feet in the Ink Hole section and 80 feet in the Bluff Creek section, results from interbedding of spiculite and calcarenite, particularly in the upper part of the unit. Along the northern side of the area where calcarenite is not appreciably interbedded, the Upper spiculite averages 30 to 40 feet in thickness, and thins eastward to 28 feet in the Pecan Grove Creek section. This slight thinning, and an increase in shale interbeds, suggest that the unit does not persist for any great distance eastward.

Upper calcarenite

This unit, in some ways similar to the Middle calcarenite, but much more variable in lithology, occupies a stratigraphic position similar to that of Plummer's (1950, p. 72) Brister Bluff member. Within my area the Upper calcarenite contains three distinct rock types, and is mappable only in local areas.

Lithology. - Thirteen feet of light gray, fine-grained, sandy limestone overlies the Upper spiculite in the Burr Tank section. Up to 30 per cent of several samples was composed of angular and rounded quartz sand grains (0.2 to 0.5 mm. in size) and subangular to subround light brown to black detrital chert grains (0.1 to 20 mm. in size.) Bedding is thin and undulose. At locality OD-4 conglomeratic material and silicified snails are exposed in relief on weathered surfaces.

Apparent eastward gradation produces a unit very similar to the Middle calcarenite. Fifteen feet of strata at the top of the Ink Hole section and 40 feet of strata that were not mapped because of poor exposure at the top of the Challenge Mill East section are composed of allochemical microcrystalline and fine-grained limestone. The allochems are carbonate intraclasts, crinoid columnals, and unidentified fossil debris. The interval in the Ink Hole section contains more identifiable algal material than it does in the Chappenge Mill East section. Black chert grains are present in the Ink Hole section at 199 and 225 feet. Light gray chert nodules are present in both sections.

In the Pecan Grove Creek section this interval, 23 feet thick, is composed of medium to dark gray, microcrystalline, cherty finely intraclastic limestone that weathers to a medium gray color. Chert is abundant in nodules and lenses, and is very similar in color to that of the Lower Marble Falls. It is light gray to black, and unfossiliferous. Bedding is thin, two to three inches, and weathering produces a steep slope.

Acetic acid residues from the sandy limestone contain quartz and chert grains, a few silicified fusulinids, fish teeth, and rare snails. From the allochemical limestone were obtained conodonts, fish teeth, bone fragments, glauconite fillings of fusulinids, limonite, and siliceous aggregates. The cherty gray limestone in the Pecan Grove Creek section contained much siliceous fossil debris, some limonite, and argillaceous material.

Areal extent and thickness. - This unit occurs in the western, northern and eastern sections. Its thickness ranges from 13 feet in the Burr Tank section to 40 feet in the Challenge Mill East section.

Smithwick Formation

Paige (1912, p. 8) defined the Smithwick as the black carbonaceous shale containing thin beds of sandstone, overlying the Marble Falls and underlying the Cretaceous. He designated the type locality as along the banks of the Colorado River near the old town of Smithwick, a few miles downstream from Marble Falls, in Burnet County. Plummer (1950, p. 79) described a section at this locality that has a thickness of 301 feet. Sellards (1933, p. 101) stated that part of these strata may be Strawn because of the numerous sandstone beds.

The name "Smithwick" has since been applied to the black and greenish-black shale overlying the Marble Falls and beneath the Strawn in the vicinity of Bend, in eastern San Saba County. There is an obscure difference between lower black hard shale and upper greenish gray shale, but it has not been demonstrated by mapping. Plummer (1950, p. 78) created an unnamed shale between the Smithwick and the Marble Falls by the following statement

> In eastern San Saba County near Bend, the basal Smithwick is 60 feet above the top of the limestone, and the base is marked by the first appearance of the coral Hadrophyllum aplatum Cummins, now named Cumminsia aplata (Cummins) by Moore and Jeffords.

In the Leonard Ranch area all shale overlying Marble Falls limestone was mapped as Smithwick. No sandstone lenses or beds were found.

Lithology. - The shale (Fig. 5) ranges in color from black to olive. Weathering has little effect on the black hard siliceous shale, but produces yellow-brown soil on the lighter colored shale, which becomes plastic when wet. Limonite and gypsum are present in varying amounts. The limonite occurs in siltstone nodules that weather to a dull red-brown color; these nodules are abundant about 2000 feet northeast of Lemons Camp.

Within the lower 20 feet of shale in the Pecan Grove Creek section are thin beds and lenses of olive gray, microcrystalline limestone that contains large amounts of pyrite and weathers to a dull reddish-brown color similar to that of the Upper spiculite.

Areal extent and thickness. - Because of poor exposure and lack of an upper boundary no section of Smithwick was measured. Its thickness could be from 50 to 300 feet.

Figure 5. - Smithwick formation, 2000 feet northwest of Lemons Camp.

Figure 6. - Upper spiculite just west of Post Oak Creek section.

STRUCTURE

Faults. - All but a few of the faults in the area strike northeast; the remainder strike northwest. No fault surfaces were found; zones of rubble, boulders, and drag up to 50° were observed along the fault just north of Lemons Camp. Mapping indicates that the faults are probably high angle and normal; several oppose one another creating large grabens. The only horst observed is in the extreme north center of the area. Good to poor exposures are found along the faults and at the ends of each graben. The number of grabens present indicates tensional forces associated with the relaxation phase of the Ouachita orogeny (Flawn, 1956, p. 59).

Faults were detected primarily from alignment discontinuities or abrupt terminations of vegetation patterns on the aerial photographs. Alluvium and low relief prevented tracing faults for any great distance and often prevented accurate location except on the photographs.

Displacement ranges from a few inches to several hundred feet. Only minimum displacement can be estimated in terms of the thickness of Carboniferous strata, for there is no dependable datum on or in the Ellenburger. Post-faulting erosion of units on both sides of a fault precludes any accurate calculation. Maximum observable displacement is probably along the fault north of Lemons Camp where sections in the vicinity show a thickness, including unmeasured Smithwick, in excess of 250 feet.

Folds. - Gentle anticlines and synclines in the Lower Marble Falls are exposed in the bed of the San Saba River from Post Oak Creek west to the junction of Brady Creek and the San Saba River. The fold axes strike N10°E, and plunge 2° to the northeast. Folds were not observed in other localities because of poor outcrops, but mapping suggests that small scale folding apparently is restricted to the Lower Marble Falls, and may be attributed to either slumping or compaction. Many of the limestone beds near the Barnett-Marble Falls boundary show small scale slumping and warping. Compaction of the Barnett, which undoubtedly varied in thickness over an irregular surface, would produce differential stresses in the overlying strata. The presence of many nonsystematic joints criss-crossing the limestone and chert beds confined to the lower five to 10 feet of the Lower Marble Falls can be interpreted as the result of post-lithification folding and jointing resulting from compaction of the Barnett.

Clastic dike. - At locality 205-T-98 (Plummer, 1950, p. 64) in Pecan Grove Creek north of Leonard Tank, a large dike-like mass of rock extends vertically into the Marble Falls to within five feet of the lower boundary of the spiculite; its base is below the Lower Marble Falls member. This dike crops out on the north and south sides of Pecan Grove Creek in two separate rock masses. It is approximately eight to 10 feet thick, and consists of dark gray, soft limestone containing many sand-sized carbonate and phosphate particles in a fine and microcrystalline matrix. Bedding is not apparent; the dike weathers to large nodular masses. Near the base of the dike large angular boulders of black microcrystalline Lower Marble Falls limestone are abundant; they decrease upward. Petrographic study and acetic acid residues show abundant phosphatic material, pellets, goniatite fragments, glauconite, and poorly preserved fragmental corals and brachiopods.

This suggests the Barnett as a source, and it is thought that the dike, composed of Barnett shale and limestone, was injected into the Marble Falls while in a plastic state.

DEPOSITIONAL HISTORY

Encroachment of the Mississippian-Pennsylvanian sea was over a surface composed entirely of Ellenburger strata that contributed little detrital material except chert fragments, sparse quartz sand grains, and possibly clay and silt from an Ellenburger soil. The chert is preserved as the Ives breccia, with the clay and silt reworked into the Barnett shale. The coarse to fine transition of the Ives-Chappel, Barnett, and Lower Marble Falls succession indicates a transgression over a surface that was contributing little detrital material, and the chert and organic fragments constituted the only sources of gravel. In this manner, the Ives and Chappel represent shore or near-shore conglomerate deposited in low areas, the Barnett represents a tidal mud-flat, relatively shallow water, and optimum conditions for marine organisms, and the Lower Marble Falls member represents a deeper, stagnant, possibly toxic, environment. Bogardus (1957, p. 107) attributes the phosphate, clay, and organic matter present in the Barnett to relatively stagnant conditions. The abundance of glauconite in the upper Barnett suggest alternating stagnant and well oxygenated conditions at a depth from 10 to 400 fathoms (Cloud, 1955). The interfingering of glauconitic dark limestone and shale near the Barnett-Marble Falls contact, the abundance of fossils in the Barnett as compared with their sparsity in the Lower Marble Falls, and the abundance of organic matter and pyrite in the Lower Marble Falls indicate a probable deeper, poorly oxygenated, reducing environment for the Lower Marble Falls, not the Barnett. This suggests that the Lower Marble Falls is the result of an adjacent but deeper, less active environment of deposition.

The Middle calcarenite and shale were probably deposited contemporaneously, and each is indicative of environmental energy. The coarseness of the bioclastic constituents, the crossbedding, and the sparry calcite cement of the calcarenite indicate relatively high energy and probably rapid deposition, possibly as a reef debris or as an elongate sand bar. Evidence for a reef is lacking at the present time. The Middle shale probably formed adjacent to the calcarenite but at a greater depth.

The Upper spiculite probably represents an even deeper water environment adjacent to the Middle shale, as shown by the widespread interfingering, inhabited mainly by spiculiferous organisms. It is recognized that the spicules would be transported by very gentle currents, but ultimately they would be deposited in the environment of least current, or the deepest environment.

The very local Upper calcarenite suggests a return to shallow water conditions, possibly regressive, with local erosion of Ellenburger and/or Lower Marble Falls contributing light gray, pink and dark chert conglomerate and quartz sand to local areas (OD-4).

No conclusive evidence was found concerning Cavern Ridge (Plummer, 1950). The conglomeratic nature of the Upper calcarenite at OD-4 indicates a local surface being subjected to erosion, and the north-south alignment of the Middle calcarenite suggests the possibility of a parallel shore line, but available information is decidedly inadequate.

BIOSTRATIGRAPHY

Chappel Formation

Roundy, Girty, and Goldman (1926) originally described the Chappel as a "Boone" limestone of Osage age. According to Cloud and Barnes (1948, p. 50) the Chappel fauna is similar to that of the Chouteau limestone of Kinderhook age, and some species are similar to those of the Fern Glen limestone of Osage age. Weller, et al. (1948) show two correlations for the Chappel; a "lower" Chappel correlated with the Chouteau and an "upper" Chappel correlated with the Fern Glen. However, Branson (1938, p. 17) records an exposure in Missouri showing interfingering of the Chouteau and Fern Glen, and states that they are unquestionably contemporaneous.

The only fossils (Fig. 8) recovered from the Chappel in my area, exclusive of crinoid fragments, are conodonts, and total 23 species in 10 genera. Of the 10 genera, Ellison (1946, p. 94) records three limited to Middle and Late Devonian, five limited to Kinderhook, one ranging from Kinderhook to Middle Osage, and one ranging from Late Devonian to Meramec. Of the 22 species previously described, Fay (1952) records six as Middle and Late Devonian, 10 as restricted to Kinderhook, and six as ranging from Kinderhook to Middle Osage (Fig. 7).

If these supposedly distinct and non-overlapping published ranges of the conodont assemblages are totaled, the Chappel was deposited during Late Devonian, Kinderhook, and Early Osage time. None of my Chappel exposures is in excess of four inches thick, and the lithology (crinoidal intrasparite and intrasparrudite) indicates a high energy environment and probably rapid deposition. A dilemma of serious proportions is created.

Examination of conodont literature reveals that a mixture of Devonian and Kinderhook forms is common, but not often reported as such. Hass (in Cloud, Barnes, and Hass, 1957) reports six zones of Devonian and Mississippian conodonts from the Ives breccia, and I have identified representative species from five of these zones in my Chappel samples. The validity of the zones is questionable, for all but two of the specimens illustrated by Hass (because they were his best specimens) were from a single sample, USGS 9264-C.

Hass (1956) illustrates a conodont fauna from the Chattanooga shale of Late Devonian age that contains nine species reported from the Bushberg and Hannibal formations of Kinderhook age (Branson and Mehl, 1934b). Ellison (1946, p. 101) states that the Bushberg fauna described by Branson and Mehl (1933) contains also Devonian and Ordovocian species, but that Branson and Mehl attempted to describe only the new forms they believed were Mississippian in age. This reveals the fact that conodont ranges have been interpreted, not factually recorded, which precludes any attempt at accurate assignment of age to the Chappel in my area.

The presence of Devonian species in a "mixed fauna" of Devonian and Kinderhook species has invariably been explained by erosion of some Devonian formation that contributed its specimens to younger deposits. Obviously, "reworked" species have been identified on the basis of assumed stratigraphic ranges, and not by the condition of the specimens. This line of reasoning can only be justified by believing in systemic unconformities, and in "formations" identified solely on faunal content. Such formations cannot transgress formal time-scale boundaries, or be recorded as younger at one place than another.

Each of the Chappel exposures studies yielded slightly different conodont assemblages that form no evident pattern. The largest number of Devonian species are from the base of the Challenge Mill North section and OD-6. All species of Bactrognathus are from the Chappel at OD-12. No attempt was made to define zones in the four inches of strata.

The presence of several species of Polygnathus, Pseudopolygnathus, and Siphonodella (Fig. 8) suggests a stronger correlation with the Bushberg of Missouri than with the Chattanooga shale that contains many species of Palmatolepis. Species of Palmatolepis, Ancyrognathus, and Polylophodonta cf. P. confluens, Polygnathus granulosa, and Polygnathus nodocostata present in the Chappel are in my opinion not reworked. The only species that is abundant in all of my Chappel samples is Polygnathus communis, and Siphonodella duplicata is very abundant at three localities. Bactrognathus excavata and B. hamata suggest a possible correlation with the Pierson of Missouri and the Sycamore of Oklahoma.

The presence in the Chappel of a conodont fauna that is widespread in North America, and apparently very similar in composition wherever found, is of some stratigraphic significance, but little factual information as to the precise ranges of its species exists.

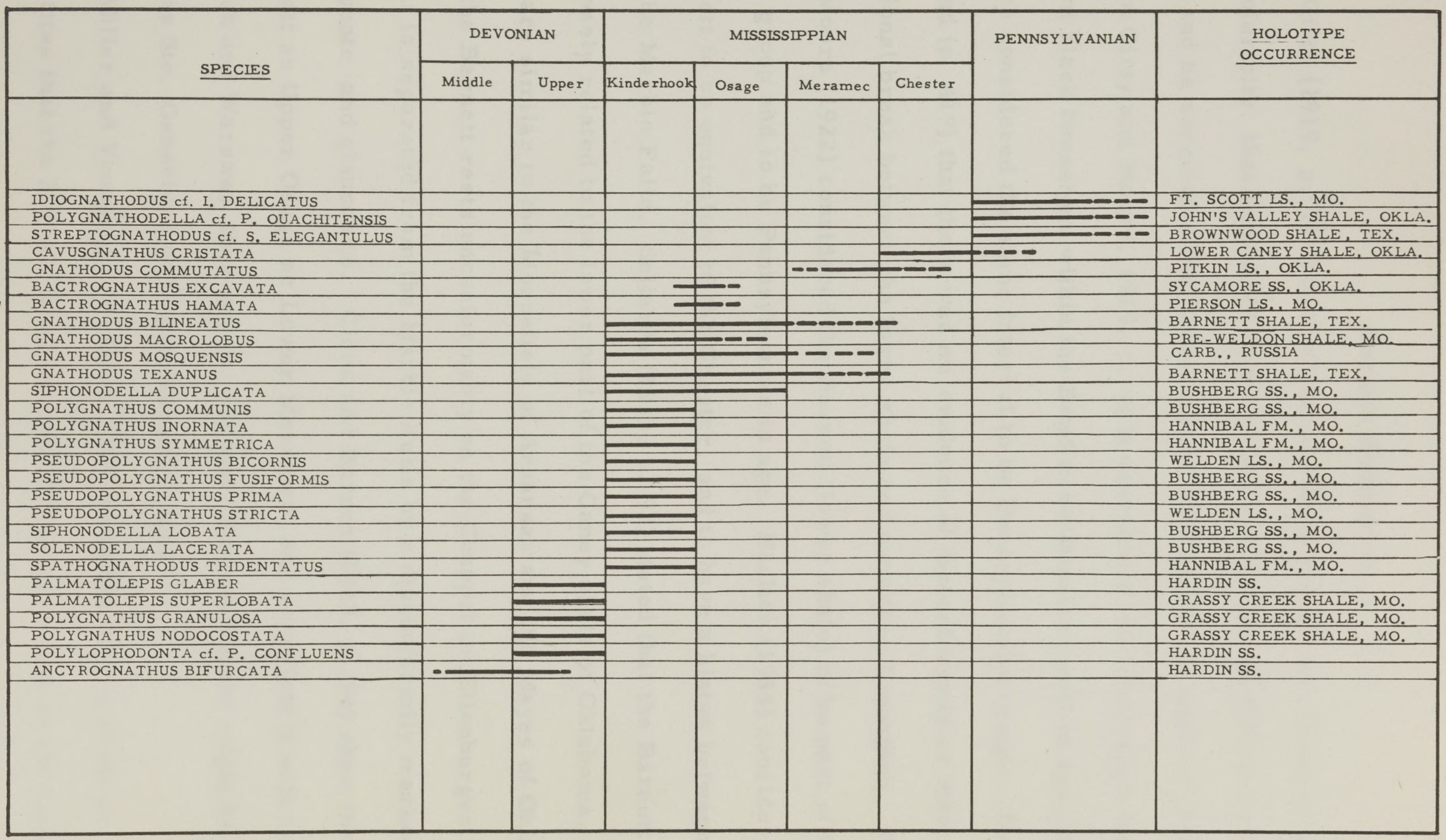


FIG. 7 PUBLISHED STRATIGRAPHIC RANGES OF CONODONT SPECIES

Barnett Formation

Girty (1919, p. 71) believed that the Bend formation contained an unconformity that separated rocks of Mississippian and Pennsylvanian age, and he correlated the "lower shale" with the Caney shale of Oklahoma. He (in Girty and Moore, 1919, p. 419) considered the lower shale and 400 feet of black limestone within the Bend to be Mississippian in age, whereas Moore considered the same interval to be Pennsylvanian in age. They agreed (p. 419) that there was no evidence of disconformity or other erosional break between the lower shale and overlying limestone. Plummer and Moore (1922) considered the Barnett (lower shale) to be part of their Bend group and to be Pennsylvanian in age. Harlton (1934) considered the Barnett to be equivalent to the Chester, and to have a hiatus between it and the Marble Falls. Sellards (1933, p. 93) stated that the Barnett is closely related to the lower part of the Caney shale of Oklahoma, that both are similar to the Moorefield of Arkansas and the Mayes of Oklahoma, that the Barnett rests unconformably on the Chappel or Ellenburger, and that it is separated from the Marble Falls by a disconformity marked by phosphate and glauconite. Cloud and Barnes (1948, p. 54) show the Barnett as Upper Osage or Lower Meramec, and correlate it with the Keokuk and Warsaw; they say (p. 59) that "the upper limit might be as high as Ste. Genevieve or Upper Meramec age."

Miller and Youngquist (1948, p. 651) concluded from a study of goniatites that the Barnett is approximately the same age as the Caney of Oklahoma, the Moorefield, Ruddell and/or lower Fayetteville of

Arkansas, and the Meramec of Kentucky. Plummer (1950, p. 43) believed the Barnett, the Moorefield, and the lower Chester to be more or less equivalent, and assigned all of them to the Chester Series.

Weller, et al. (1948) were of the opinion that the Barnett is similar lithically and faunally to the lower part of the Caney of Oklahoma, and expressed the doubt that any strata of Chesteran age crop out. However, on the correlation chart the Barnett is shown in two parts; a lower Barnett correlated with the Warsaw or St. Louis, and an upper Barnett correlated with the Paint Creek of the Lower Chester Series.

The fauna recovered from the Barnett (Fig. 8) in my area consists of three species of brachiopods, one of goniatite, one of coral, and six of conodonts. Marginifera cf. M. welleri and Cladoconus cf. C. fragilis are present in the Morrow group of Oklahoma (Mather, 1915), and Avonia cf. A. blairi is reported from the Chouteau by Weller (1914). Of the seven species of conodonts, Gnathodus texanus (also found in the Chappel) is reported from the Welden limestone (Taylor, 1941) and from the lower Caney (Branson and Mehl, 1941a). Gnathodus commutatus is recorded from the Pitkin limestone, of Late Chester age (Branson and Mehl, 1941) and from the Ives breccia member of the Houy formation (Cloud, Barnes, and Hass, 1957). Cavusgnathus cristata is reported from the Caney shale (Branson and Mehl, 1941a).

From the upper glauconitic interval Polygnathodella cf. P. ouachitensis, described from the Johns Valley shale by Harlton (1934), and Strepto-gnathodus cf. S. elegantulus, described from the Brownwood shale by

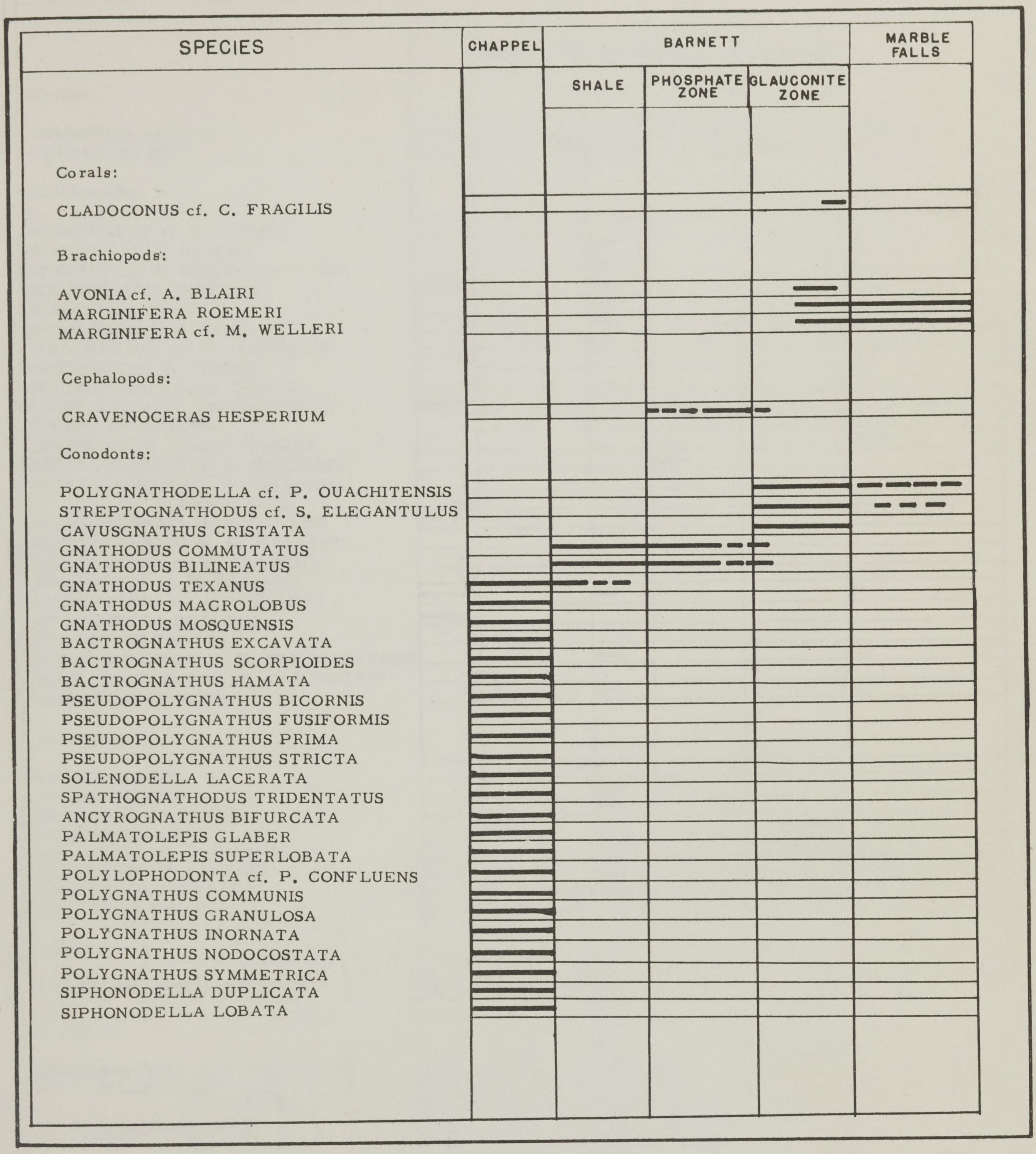


Fig. 8. Faunal chart of Chappel and Barnett formations.

SPECIES	MARBLE FALLS					SMITHWICK
	LOWER	MIDDLE		UPPER		
		CALCARENITE	SHALE	SPICULITE	CALCARENITE	
Corals:						
CUMMINSIA APLATA						—
CHAETETES SP.		—				
Brachiopods:						
NEOSPIRIFER cf. N. GOREII	—					
SPIRIFER cf. S. OPIMUS			—			
SPIRIFER cf. S. ROCKYMONTANUS			—			
SQUAMULARIA PERPLEXA	—		—			
COMPOSITA OVATA			—			
COMPOSITA OZARKANA	—		—			
WELLERELLA cf. W. OSAGENSIS			—			
HUSTEDIA cf. H. MISERI	—					
SCHIZOPHORIA cf. S. TEXANA	—					
CHONETES cf. C. CHOTEAUENSIS	—					
CHONETES DOMINUS			—			
CHONETES cf. C. GRANULIFER						—
DICTYOCLOSTUS cf. D. INFLATUS				—		
DICTYOCLOSTUS cf. D. INFLATUS var. COLORADOENSIS	—					
DICTYOCLOSTUS MORROWENSIS	—					
DICTYOCLOSTUS cf. D. WELLERI			—			
HETERALOSIA cf. H. SLOCUMI	—					
HORRIDONIA cf. H. GLOBOSA	—					
MARGINIFERA cf. M. WELLERI	—		—			
MARGINIFERA ROEMERI	—					
PRODUCTUS PARVUS	—					
PUNCTOSPIRIFER cf. P. KENTUCKYENSIS			—			
PUNCTOSPIRIFER cf. P. CAMPESTRIS	—					
LINOPRODUCTUS SP.			—			
Gastropods:						
NATICOPSIS SP.		—	—			
EUPHEMITES SP.			—			
ORTHONYCHIA PARVA			—			
SPAERODOMA SP.					—	
STRAPAROLUS PLUMMERI					—	
STRAPAROLUS SAVAGEI						—
WORTHENIA TABULATA			—			
BELLEROPHON SP.					—	
Cephalopods:						
PHANEROCERAS COMPRESSUM						—
Conodonts:						
IDIOGNATHODUS cf. I. DELICATUS					—	
POLYGNATHODELLA cf. P. OUACHITENSIS	- - -	- - -	- - -	- - -	—	
STREPTOGNATHODUS cf. S. ELEGANTULUS	- - -	- - -	- - -	- - -	—	

Fig. 9. Faunal chart of Marble Falls and Smithwick formations.

Stauffer and Plummer (1932), are present in every sample.

This limited fauna provides no evidence for a paleontologic hiatus and the Barnett is assumed to represent all geologic time from the upper limit of the Chappel to the lower limit of the Marble Falls at any locality. As mapped, the glauconitic interval at the top of the Barnett is Pennsylvanian in age.

Zones. - Specimens of Polygnathus cf. P. ouachitensis and Streptognathodus cf. S. elegantulus are extremely abundant in the glauconitic interval of the Barnett, and have not been found lower, nor has Cavusgnathus cristata. A single collection from 21 feet in the Challenge Mill section yielded the only identifiable goniatites (Cravenoceras hysperium) but the "pellet" beds of phosphatic debris contain many goniatite fragments and apparently are laterally persistent. Below the "pellet" beds the only species that appear consistently are Gnathodus bilineatus and G. commutatus.

Marble Falls Formation

Literature pertaining to the Marble Falls prior to 1940 dealt mainly with rock units and their faunas. Subsequent work has dealt almost entirely with time-stratigraphic relationships and age determinations based on fusulinid collections. Much of this work (Thompson, 1942, 1947; Spivey and Roberts, 1946; Moore, et al., 1944; Moore and Thompson, 1949) provides little information pertinent to my problem. Factual data are minimal but regional correlations are profuse; these interpretations were always stated in terms of the vaguely defined rock units of Plummer and Cheney, and the result can be described as "progressive confusion".

From the Marble Falls of my area (Fig. 9), I have identified 22 species and one variety of brachiopods, four named species among seven genera of gastropods, one genus of coral, and three species of conodonts. Of this fauna, 14 species of brachiopods and the coral are present in the Morrow of Oklahoma (Mather, 1915), four brachiopod species occur in the Marmaton and Kansas City groups (Dunbar and Condra, 1932).

Collections from the Lower Marble Falls member came entirely from black limestone whereas those from the Middle shale came from either shale or shaly limestone. The faunal chart (Fig. 9) shows an almost completely different fauna for the Lower Marble Falls and the Middle shale. The inclusion of the Middle calcarenite gives the impression of a distinct stratigraphic separation. Over the eastern half of my area, where the Middle calcarenite is absent, I doubt if this distinction would be so strong.

Zones. - Establishment of zones within the Marble Falls is not feasible on the basis of my limited information. Many of the species were collected from a single locality, and several are represented by a single specimen. These facts preclude any reasonably certain statements relating to ranges vertically or horizontally.

The most abundant species in the Lower Marble Falls are Marginifera cf. M. welleri, M. roemeri, and Chonetes cf. C. chouteauensis; the latter two have not been found above the Lower Marble Falls. Large stump-like colonies of *Chaetetes* commonly are present on the upper surface of the Middle calcarenite, and have not been found abundantly elsewhere in the section. Specimens of *Linoproductus* are extremely abundant in the shaly limestone and calcareous concretions of the Middle shale; they are invariably crushed and fragmental.

The majority of species recorded from the Middle shale are from OD-2 and OD-7. At locality OD-7 many discrete crinoid columnals and other disarticulated and abraded fossil debris suggests a thanatocoenosis.

Polygnathodella cf. *P. ouachitensis* and *Streptognathodus* cf. *S. elegantulus* are rare throughout the Marble Falls. *Idiognathodus* cf. *I. delicatus* is the only conodont from the Marble Falls that does not also occur in the Barnett; it was obtained from the calcarenitic beds of the Upper Marble Falls.

Smithwick Formation

Only four species (Fig. 9) are identified from the Smithwick shale and these were collected from OD-3 and OD-10. The only species that occurs at both localities is *Cumminsia aplata*. Fossils are extremely rare in the black shale and occur only in local concentrations.

SYSTEMATIC PALEONTOLOGY

The fossils described from the Leonard Ranch area are corals, brachiopods, gastropods, cephalopods, and conodonts, and are described in that order. Genera and species are listed alphabetically under the next higher taxon. The best specimens were in general recovered from limestone by etching with acid. Conodonts were recovered from limestone by etching with 10% acetic acid, and from shale by boiling with sodium carbonate. Silicification of the brachiopods and snails ranged from excellent to very poor. Specimens collected from the Middle shale were often incomplete and badly crushed.

Occurrences are recorded by footage in measured sections described in detail in Appendix A, and from the following isolated localities: the Lower Marble Falls member -- OD-1, west of Maxwell Crossing; the Middle shale -- OD-2, near Lemons Camp, OD-7, north of the Nell Sloan ranch house, OD-9, west of the Leonard Ranch headquarters, OD-13, near Leonard Tank; Upper calcarenite -- OD-4, southwest of Burr Tank; and from the Smithwick formation -- OD-3, near Burr Tank, OD-10, near Ellis Crossing.

Samples of Chappel were recovered from the base of the Challenge Mill North and the Leonard Tank section, and from localities OD-5, east of Hackberry Mill, OD-6, north of the Nell Sloan ranch house, and OD-12 southwest of Leonard Tank.

PHYLUM COELENTERATA

CLASS ANTHOZOA

Genus CLADOCONUS McCoy 1847

CLADOCONUS cf. C. FRAGILIS Mather

Plate 4, figure 10

Cladoconus fragilis MATHER, 1915, p. 98, pl. I, fig. 3-5; MOORE and JEFFORDS, 1945, p. 186, pl. 14, fig. 1-3.

Branching colonial corallum comprised of delicate funnel-shaped corallites. Corallites do not possess tabulae; calyx circular with walls thickening toward base of corallite. Single buds are given off at an angle to parent bud; they develop alternately and face in opposite directions. Outer surface is smooth.

Occurrence: Abundant in upper Barnett at 21 feet in Challenge Mill section.

Genus CUMMINSIA Moore and Jeffords 1945

CUMMINSIA APLATA (Cummins)

Plate 4, figure 5

Hadrophyllum aplatus CUMMINS, 1891, p. 552.

Hadrophyllum aplatum Cummins BASSLER, 1937, p. 200, pl. 32, fig. 19-20.

Cumminsia aplata (Cummins) MOORE AND JEFFORDS, 1945, p. 166, pl. 14, fig. 16-23.

Solitary corralite, corallum discoidal, lowly cylindrical, base nearly flat with elevated peduncle, and covered with concentric growth lines. More elongate forms appear to be built up of a series of discs. Diameter ranges from 15 to 25 mm. and thickness ranges from six to 15 mm. A large deep fossula, longer than radius, bears very short cardinal septum; fossula deepest at axis, rising abruptly in central part. Septa arranged in four groups separated by cardinal and counter septa, separated by two alar pseudofossulae that appear to be two fused septa. Septa are highest near center, decreasing in height to periphery where they terminate on a raised ridge. Septa are thin straight plates; there are seven between the cardinal and alar, and five between alar and counter.

PHYLUM BRACHIOPODA

CLASS ARTICULATA

IMPUNCTATE ARTICULATA

SUPERFAMILY ORTHACEA

FAMILY SCHIZOPHORIIDAE

Genus SCHIZOPHORIA King 1850

SCHIZOPHORIA cf. S. TEXANA Girty

Plate 3, figures 8, 10

Schizophoria texana GIRTY, 1928, p. 432, pl. 27, fig. 1-8.

Ventral exterior: Length very nearly equals width, ratio about four to five, greatest width near midlength. Evenly convex, greatest over visceral area and flattening laterally and anteriorly. A broad shallow sulcus at the anterior quickly disappears about one-third length from anterior. Surface covered by costellae, four per mm.; more prominent but short costellae, every two or three mm., project above the surface of the valve. Cardinal angle obtuse, beak small, projecting past hinge line.

Ventral interior: Interarea short, broad delthyrium. Dental lamellae enclose two elongate diductor muscle scars separated by a short median septum that has its maximum height near its anterior end. Median septum decreases in height posteriorly and has an arcuate profile. Septum is joined to dental lamellae at anterior end by a low broad callus-like ridge that encircles anterior end of muscle scars. Surface covered by fine costellae as on exterior.

Occurrence: Single valve from Lower Marble Falls in Challenge Mill North section.

SUPERFAMILY RHYNCHONELLACEA

FAMILY CAMAROTOECHIIDAE

Genus WELLERELLA Dunbar and Condra 1932

WELLERELLA cf. W. OSAGENSIS (Swallow)

Plate 2, figure 5

Rhynchonella (Camarophoria) Osagensis SWALLOW, 1858, p. 219.

Wellerella osagensis (Swallow) DUNBAR and CONDRA, 1932, p. 288, pl. XXXVII, figs. 1-4.

Wellerella utah (Swallow) PLUMMER, 1950, pl. 14, fig. 6.

Ventral exterior: Outline subglobular, triangular on posterior half and rounded on anterior half. Moderately convex with strongly rounded margins. Posterior margins straight and tapering toward beak, forming an angle of 90^{o} at their junction. Posterolateral margins steeply rounded to greatest convexity one-fourth length from beak. Surface covered by costellae and growth lines. Anterior margin gently and evenly rounded with a central broad, shallow sulcus. At mid-length three rounded plications start and increase in size toward anterior. These plications occupy the shallow sulcus.

Occurrence: Rare in Middle shale at locality OD-13.

SUPERFAMILY SPIRIFERACEA

FAMILY SPIRIFERIDAE

Genus NEOSPIRIFER Fredericks 1919

NEOSPIRIFER cf. N. GOREII (Mather)

Plate 3, figure 15

Spirifer goreii MATHER, 1915, p. 186, pl. XII, figs. 10-11a.

Neospirifer goreii (Mather) DUNBAR and CONDRA, 1932, p. 341, pl. XXXIX, figs. 1-3.

Length-width ratio approximately one to two, cardinal angle acute, fold and sulcus strong, anteriorly extended on dorsal valve. Fasiculation of plicae prominent in sulcus.

Ventral exterior: Greatest convexity just anterior to hinge line, tapers gradually in all directions toward margins. Transverse profile flatly and gently convex, increases sharply lateral to sulcus. Sulcus narrow, angular posteriorly, broader and more rounded at anterior margin. Plications broad, low, rounded; seven in sulcus anteriorly, 18 to 22 lateral to sulcus. Fasiculate plications much stronger near sulcus, fading out near cardinal extremities. Beak prominent and curved over large delthyrium; interarea large, concave and at right angle to plane of commisure.

Occurrence: Single specimen in spiculitic limestone near top of Lower Marble Falls at OD-1.

Genus SPIRIFER Sowerby 1814-18

SPIRIFER cf. S. OPIMUS Hall

Plate 3, figures 4, 6

Spirifer opimus HALL, 1858, pl. XXVIII, p. 711, figs. 1a-b; MATHER, 1915, p. 185, pl. XII, figs. 7-7c; DUNBAR and CONDRA, 1932, p. 320, pl. XXI, figs. 10-11c.

Shell rotund, thick, with strong fold and sulcus. Plications are low, broad, and very regular.

Ventral exterior: Strongly convex transversely, sulcus prominent at anterior. Anterior margin gently rounded except for projection of fold and sulcus. Sulcus bears three plications in bottom of trough, one between upper and lower limits of sulcus on each side, and 12 to 13 lateral to sulcus. Plications are low, broad, with narrower grooves between them.

Dorsal exterior: Moderately convex. Fold sharp, anteriorly has central plications bounded by a large one on each side; they converge and completely disappear near beak. The two central plications are bordered laterally by pronounced grooves. The first plication lateral to fold bifurcates near apex and forms two equal plications at anterior margin. Twelve to 13 non-bifurcating and regular plications are lateral to fold; they decrease in width and prominence toward cardinal extremities.

Occurrence: Common in lower 10 feet of Middle shale at OD-2.

SPIRIFER cf. S. ROCKYMONTANUS Marcou

Plate 3, figure 13

Spirifer rocky-montani MARCOU, 1858, p. 50, pl. VII, figs. 4c, d, e (not figs. 4 a, b).
Spirifer rockymontanus Marcou GIRTY, 1903, p. 383, pl. VI, figs. 5-7c; DUNBAR and CONDRA, 1932, p. 318, pl. XLI, figs. 7-9; PLUMMER, 1950, pl. 12, figs. 1a-c.

Shell small, width greater than length, greatest width at hinge line; margin gently rounded to cardinal extremities. Large beak curved over large triangular delthyrium.

Ventral exterior: Five plications in broad, shallow sulcus at anterior; none reach beak. At beak a simple plication lies on each side of smooth sulcus; about 0.5 cm. from beak a single plication is evident in center of sulcus. Lateral to this, and on each side of the sulcus, the first plication bifurcates; at about one cm. from beak a pair splits off from the central plication. The inner plication of the bordering pair plus the three that originate in the sulcus comprise the five in the sulcus at the anterior margin. Lateral to the sulcus are nine to 13 broadly rounded low plications.

Occurrence: Single specimen found in the lower 10 feet of Middle shale at OD-2.

Genus SQUAMULARIA Gemmellaro 1899

SQUAMULARIA PERPLEXA (McChesney)

Plate 3, figure 14

Spirifer perplexa McCHESNEY, 1860, p. 43.

Squamularia perplexa (McChesney) GIRTY, 1903, p. 392, pl. VI, figs. 8-10a; ibid., 1915, p. 92, pl. XI, figs. 1-3a; MATHER, 1915, p. 188, pl. XII, figs. 13-13a; DUNBAR and CONDRA, 1932, p. 313, pl. XLII, figs. 5-8; PLUMMER, 1950, pl. 12, fig. 10.

Biconvex, length and width equal. Cardinal extremities small and gently rounded. Surface covered with bands of small spines arranged in overlapping rows. The spines lie very close to the surface and give it a radially striate appearance. Beak large, overhanging hinge line.

Ventral exterior: Roundly convex, gentle flattening over umbonal area. Beak large, unbonal slopes steep and cover major portion of valve. Surface of valve marked by low broad elevated bands covered by many anteriorly directed, very small spines.

Dorsal exterior: Hinge line straight; cardinal extremities rounded. Convexity least at anterior, increases gradually toward posterior. Ornamentation same as ventral valve but spines are confined to anterior one-fourth of valve.

Occurrence: Rare in Lower Marble Falls at eight feet in Challenge Mill East section, and in Middle shale at OD-7.

SUPERFAMILY ROSTROSPIRACEA

FAMILY ATHYRIDAE

Genus COMPOSITA Brown 1849

COMPOSITA OVATA Mather

Plate 3, figures 9, 11, 16

Composita ovata MATHER, 1915, p. 202, pl. XIV, figs. 6-6c; DUNBAR and CONDRA, 1932, p. 370, pl. XLIII, figs. 14-19; PLUMMER, 1950, pl. 12, fig. 17.

Biconvex; ventral side globular, and dorsal side subcircular, rounded fold and sulcus. Surface covered by faint concentric growth lines increasingly pronounced anteriorly, every fourth or fifth stronger. Large beak extends past short hinge line. Convexity greatest near posterior, tapering quickly toward lateral margins and gradually toward anterior.

Ventral exterior: Almost pentagonal in outline, greatest convexity one-third length from posterior. Large beak projects past and slightly overlaps dorsal valve. Surface covered by growth lines that become evident just posterior to mid-length and increase in sharpness anteriorly, every fourth or fifth is more pronounced. Sulcus originates one-fourth length from anterior; its width is approximately one-third of the valve. A faint shallow groove originates on beak, and becoming stronger anteriorly, occupies the center of the sulcus. A large, elliptical foramen is on dorsal side of beak.

Dorsal exterior: Outline almost circular, gently convex. Concentric growth lines are evident on anterior one-fourth of valve. Low fold extends back one-fourth length from anterior and is bordered by slight indentations.

Occurrence: Abundant in Middle shale at OD-7.

COMPOSITA OZARKANA Mather

Plate 3, figures 5, 7

Composita ozarkana MATHER, 1915, p. 196, pl. XIII, figs. 11-15c.

Composita trilobata DUNBAR and CONDRA, 1932, p. 372, pl. XLIII, figs. 25-31.

This species differs from Composita ovata in the more pronounced fold and sulcus, the development of a lateral sulcus on each side of the fold, more triangular outline, greater shell depth, and absence of the median groove on the ventral valve.

Occurrence: Abundant in Middle shale at OD-2, OD-7. A single specimen was found in Lower Marble Falls at eight feet in the Challenge Mill section.

FAMILY RHYNCHOSPIRINIDAE

Genus HUSTEDIA Hall and Clarke 1893

HUSTEDIA cf. H. MISERI Mather

Plate 3, figures 1, 2

Hustedia miseri MATHER, 1915, p. 196, pl. XIII, figs., 4-6a.

Biconvex, length greater than width, beak large, outline globular, elongate. Surface sharply plicate, with 20 to 22 plications on each valve.

Ventral exterior: Greatest convexity transversly across umbonal area with gradual taper anteriorly. Beak prominent, extending past short straight hinge line and overlapping dorsal valve slightly. Round foramen is at termination of beak.

Dorsal exterior: Beak smaller than on ventral valve. Convexity less and valve appears more rounded.

Occurrence: Common in spiculitic limestone at top of Lower Marble Falls at OD-1.

PSEUDOPUNCTATE ATRICULATA

SUPERFAMILY PRODUCTACEA

FAMILY CHONETIIDAE

Genus CHONETES Fischer 1830-37

CHONETES cf. C. CHOTEAUENSIS Mather

Plate 1, figures 12, 14, 18

Chonetes choteauensis MATHER, 1915, p. 150, pl. VIII, figs. 9-10a; MORNINGSTAR, 1922, p. 178, pl. VII, figs. 16-18.

Chonetina choteauensis (Mather) PLUMMER, 1950, pl. 12, fig. 8.

Almost rectangular in shape, definite anterior flattening of margin. Length-width ratio about three to five. Cardinal extremities approach a right angle. Hinge line almost straight with slight slope anteriorly from beak. Moderately concavo-convex. Costellae abundant, strongest around margin. Each side of hinge line bears four or five spines.

Ventral exterior: Strongest convexity one-third length from anterior. Median sulcus well developed and broad near anterior margin, dying out by mid-length.

Dorsal exterior: Evenly concave with greatest concavity near anterior margin.

Ventral interior: Large triangular delthyrium, narrow interarea. Broad hinge teeth project from junction of proparea and delthyrium. Short median septum ends abruptly at mid-length. Numerous papilli are most pronounced along margin and are superimposed on faint costellae along anterior margin.

Occurrence: Apparently restricted to Lower Marble Falls; common at eight feet in Challenge Mill East section, in Challenge Mill North section, and at OD-1.

Discussion: This species lacks the sharp fold and sulcus characteristic of the genus Chonetina.

CHONETES DOMINUS King

Plate 1, figures 16, 17

Chonetes dominus KING, 1938, p. 259, pl. 36, figs. 1-7; PLUMMER, 1950, pl. 14, fig. 2.

Concavo-convex; almost rectangular, length-width ratio of two to three. Lateral margins straight and at right angle to hinge line, anterior margin rounded. Beak small, barely projecting past hinge line. Surface covered with fine radiating costellae, six per mm. at mid-length.

Ventral exterior: Slightly and broadly convex, greatest convexity one-third length from posterior. Hinge line almost straight, with small central beak. Broad shallow sulcus at anterior dies out just anterior to hinge line. Each side of hinge line has six spines. Three to four concentric growth lines confined to anterior one-fourth. Cardinal extremities flat, very gentle increase in convexity toward each side of sulcus. Small partial deltidium covers part of triangular delthyrium in center of laterally striated interarea.

Dorsal exterior: Valve broadly, flatly concave. Shallow laterally projecting sulcus anterior to and paralleling hinge line.

Occurrence: Common in Middle shale at OD-2, OD-9, OD-13.

CHONETES cf. C. GRANULIFER Owen

Plate 1, figure 8

Chonetes granulifer OWEN, 1853, tab. 5, figs. 12a-d; DUNBAR and CONDRA, 1932, p. 138, pl. XVIII, figs. 1-10.

Concavo-convex, semi-circular in outline, acute cardinal angle and strong rounding of anterior margin. Longitudinally evenly and moderately convex; sides taper steeply upward to a broad flat central area over visceral area. Beak pronounced, projecting past hinge line. Hinge line shows four to six spines on each side.

Ventral exterior: Longitudinally moderately convex, steepest on posterior and flattening gradually anteriorly. Umbonal elevation distinct on posterior one-third but merges with general curvature. Umbo pronounced, extending past hinge line. Surface covered with radiating costellae, 11 per 2 mm., that bear many small pits, 7 per mm. Costellae most pronounced on central one-third of valve.

Dorsal exterior: Usually badly crushed but having same ornamentation. Cardinal process bears four radially projecting lobes.

Occurrence: Common in Smithwick shale at OD-3.

Discussion: Chonetes cf. C. choteauensis differs from C. dominus and C. granulifer by its more rectangular outline, greater convexity, and the presence of a definite low, broad sulcus. Chonetes granulifer is more convex and more rounded in outline than C. dominus.

FAMILY PRODUCTIDAE

Genus AVONIA Thomas 1914

AVONIA cf. A. BLAIRI (Miller)

Plate 2, figure 9

Productus blairi MILLER, 1891, p. 689, pl. 13, figs. 16 (not fig. 17); WELLER, 1914, p. 110, pl. XIV, figs. 14-21.

Avonia blairi PLUMMER, 1950, pl. 5, fig. 2, 5.

Globose, length equals width, extremely convex, covered by strong concentric rugae spaced little more than a millimeter apart and each bearing a single row of spines that lie near shell surface and project anteriorly.

Ventral exterior: Beak much enlarged, extends past and slightly overlaps hinge line. Umbonal area much inflated and extremely convex. Cardinal extremities small, no sharp distinction from steep umbonal slope. Single row of spines directed anteriorly along base of umbonal slope.

Occurrence: Single specimen in Barnett at 15.5 feet in Pecan Grove Creek (B) section.

Genus DICTYOCLOSTUS Muir-Wood 1930

DICTYOCLOSTUS cf. D. INFLATUS (McChesney)

Plate 1, figures 1, 4

Productus inflatus McCHESNEY, 1860, p. 40; ibid, 1868, p. 27, pl. 6, figs. 1a-c; WELLER, 1914, p. 111, pl. X, figs. 1-6.

Dictyoclostus inflatus (McChesney) PLUMMER, 1950, p. 18, fig. 13.

Shell of medium size, width about three centimeters anterior to hinge line and geniculate.

Ventral exterior: Extremely convex, narrow, highly inflated umbo and large cardinal extremities. Umbo strongly triangular, concentrated posterior to hinge line. Beak strongly incurved overlapping hinge line. Relatively narrow, rounded sulcus originates on umbo. Base of umbonal slope strongly marked by wrinkles that do not extend to upper surface of umbo; angle of umbo and cardinal extremities near 90°. Surface of valve costate, eight per five mm. on umbonal slope, increasing in size and number by implantation to six per five mm. on anterior. Spines distributed over entire valve, concentrations on cardinal extremities and along base of umbonal slope.

Occurrence: Single specimen in Upper Marble Falls at 106 feet in the Challenge Mill North section.

DICTYOCLOSTUS cf. D. INFLATUS var. COLORADOENSIS (Girty)

Plate 1, figure 13

Productus inflatus var. coloradoensis GIRTY, 1910, p. 215; ibid., 1911, p. 42, pl. IV, fig. 3; ibid, 1915, p. 47, pl. III, figs. 7-8a.

Dictyoclostus inflatus var. coloradoensis (Girty) PLUMMER, 1950, pl. 12, fig. 9.

This variety is identified by the broader triangular shape of the umbo, less abundant development of spines, stronger reticulation that extends entirely over the posterior half ot the umbo, and only a faint median flattening. The umbo is broader and less inflated than in Dictyoclostus inflatus.

Occurrence: Common in Lower Marble Falls at 60 feet in Challenge

Mill North section.

DICTYOCLOSTUS MORROWENSIS (Mather)

Plate 1, figure 10, 15

Productus morrowensis MATHER, 1915, p. 152, pl. X, figs. 1-4a.

Dictyoclostus morrowensis (Mather) PLUMMER, 1950, pl. 11, figs. 4, 6.

Geniculate, concavo-convex, length greater than width. Umbo highly inflated. Surface covered with regular straight costae, 2 per mm. Reticulation strong on both valves.

Ventral exterior: Strongly convex, broad high umbo with large, obtuse strongly overlapping beak. Most of umbonal area is posterior to hinge line. Cardinal extremities small, showing distinct margin at base of umbonal slope. Angle at junction of umbonal slope and cardinal extremities greater than 90°. Umbonal area broad, highly inflated with distinct median flattening. Reticulation strong, extending back from beak three or four cm.

Dorsal exterior: Geniculate, with well defined circular visceral disc and pronounced reticulation over entire disc.

Occurrence: Abundant in Lower Marble Falls at eight feet in Challenge Mill East section, and at 60 feet in Challenge Mill North section.

Discussion: Dictyoclostus morrowensis differs from Dictyoclostus cf. D. inflatus by its lack of a median sulcus, coarser costae, more pronounced reticulation, and apparently stronger geniculation. Dictyoclostus cf. D. inflatus var. coloradoensis lacks a median sulcus, but the umbonal area is broader and much less inflated.

DICTYOCLOSTUS cf. D. WELLERI King

Plate 2, figures 4, 7, 8

Dictyoclostus welleri KING, 1938, p. 273, pl. 39, figs. 5-8.

Ventral exterior: Extremely convex, width equal to length, about 4.5 cm. Most of visceral area is posterior to hinge line; umbo highly inflated, beak enlarged, and overlapping hinge line. Reticulation strong on posterior one-third, fading out anteriorly. Large spines over entire surface but not numerous. Broad shallow sulcus originates on umbo, just anterior to beak with a slight increase in width toward anterior. Surface costate, one per mm.

Occurrence: Abundant in Middle shale at OD-2.

Discussion: Size is the major identifying feature. This species is very similar to D. morrowensis but is much larger.

Genus HETERALOSIA King 1938

HETERALOSIA cf. H. SLOCOMI King

Plate 1, figures 9, 11

Heteralosia slocomi KING, 1938, p. 278, pl. 39, figs. 15-18.

Subcircular, flatly concavo-convex, greatest width anterior to mid-length. Cardinal extremities small. Very low, broad umbo has circular disc, cicatrix, for attachment. Surface covered by spines four to five mm. projecting above shell surface at an acute angle anteriorly. Spines are confined to ventral valve.

Ventral exterior: Lowly and evenly convex with cicatrix on broad umbo. Cardinal extremities small, angle obtuse. Spines project radially giving a very distinctive appearance to valve. Interarea broadly triangular containing narrow elongate delthyrium.

Dorsal exterior: Broadly concave, strong concentric growth lines or wrinkles over entire surface. Cardinal line straight.

Occurrence: Abundant in spiculitic limestone near top of Lower Marble Falls at OD-1.

Genus HORRIDONIA Chao 1927

HORRIDONIA cf. H. GLOBOSA (Mather)

Plate 2, figures 3, 6

Pustula globosa MATHER, 1915, p. 167, pl. X, figs. 7-9.

Horridonia globosa (Mather) PLUMMER, 1950, pl. 11, fig. 2.

Concavo-convex, globular, length greater than width. Hinge line short. Beak large, overlapping hinge line. Umbonal area strongly convex. Greatest width at mid-length. Surface of both valves covered with large, evenly spaced, but random spines.

Ventral exterior: Umbonal area strongly convex, tapers steeply toward cardinal extremities. Cardonal angle obtuse. Beak large, projecting past and overlapping hinge line.

Dorsal exterior: Strongly and evenly concave. Hinge line almost straight. Faint concentric growth lines cover entire valve. Large spines project from valve surface at a large acute angle; their distribution is random but they are evenly spaced.

Occurrence: Rare in upper Barnett at 21 feet in Challenge Mill section.

Genus MARGINIFERA Waagen 1884

MARGINIFERA ROEMERI Girty

Plate 1, figures 5, 6

Marginifera roemeri GIRTY, 1937, p. 264, pl. 67, figs. 8a-b, pl. 70, figs. 12, 14-17.

This species differs from Marginifera welleri in possessing a definite median sulcus originating on the umbo near the beak, coarser costae that become faint on large specimens, and smaller cardinal extremities that have a deeper, more pronounced pit on the ventral interior. Length is closer to width with a ratio of seven to nine. Spines fewer, none on cardinal extremities and only two along base of umbonal slope. Large spines are present along anterior margin in two offset rows.

The dorsal valve has much coarser internal structure. A larger median septum is bordered by a subcircular low ridge that encircles visceral area on each side of septum. The area anterior to the septum and the circular raised areas is covered by large cone-shaped short spines.

Occurrence: Abundant in upper Barnett at 15.5 feet in Pecan Grove Creek (B) section, and 21 feet in the Challenge Mill section. It also occurs in Lower Marble Falls in the Challenge Mill North section and at eight feet in the Challenge Mill East section.

MARGINIFERA cf. M. WELLERI (Mather)

Plate 1, figures 2, 3, 7

Productus welleri MATHER, 1915, p. 155, pl. IX, figs. 10-11a.

Linoproductus welleri (Mather) PLUMMER, 1950, pl. 12, fig. 7.

Concavo-convex, length-width ratio approximately two to three. Hinge line straight, lateral and anterior margin evenly rounded from cardinal extremities. Cardinal angle acute to nearly 90°. Cardinal extremities large and flat. Longitudinal profile shows moderate and even convexity. Transverse profile shows steep umbonal slopes near margins that flatten quickly over a broad central umbo. Consistent median flattening originates just posterior to mid-length. Surface evenly costate, eight per five mm. at mid-length, and spinose. Reticulation is confined to posterior half.

Ventral exterior: Strongly convex, large tapering umbo distinct from large flat cardinal extremities. Umbonal slope steep, ornamented just above its base by a single row of three to four spines projecting laterally and posteriorly. These spines increase in size anteriorly. Beak large, projecting past hinge line. Cardinal extremities ornamented with three to four spines in a row along hinge line near beak; they move toward ventral surface near lateral margin and increase in size away from beak. Spines are distributed over entire surface of valve, larger ones along anterior margin. Reticulation is strong over umbonal area, fading out on cardinal extremities and along anterior.

Dorsal exterior: Evenly concave, distinct flattening near cardinal extremities. Strongest concavity just anterior to cardinal process.

Surface not spinose; reticulation over entire surface.

Ventral interior: Pronounced marginal flange encircles edge of valve. Flat surface of cardinal extremities marked by a shallow pit. Anterior surface of valve marked by fine costellae, 20 to 23 per five mm., evident along internal edge of flange.

Dorsal interior: Marginal callus-like ridge prominent along posterior and sides of valve. Lobed cardinal process projects past hinge line from a raised marginal platform dilineating visceral area from cardinal extremities. Visceral area raised above the level of the valve, bordered by marginal ridge covered by short, small papilli. Marginal ridge diverges from under cardinal process at about 20° from posterior to near lateral margin where it then curves toward anterior, becoming less evident on anterior half of valve. Short high median septum in center of valve has abrupt anterior termination. Posteriorly, the septum becomes lower more gradually, lying in a shallow broad groove. Posterior to this groove and between the groove and ridge are two lobate, depressed muscle scars. The area between the muscle scars and the median septum slightly raised and covered with short blunt papillose spines. The area anterolateral to the septum is covered with 18 to 22 short, quickly tapered spines that project anteriorly.

Occurrence: Abundant in upper Barnett, Lower Marble Falls, and Middle shale. It occurs in the Barnett at 21 feet in the Challenge Mill section, in the Lower Marble Falls at eight feet in the Challenge Mill East section, and at OD-1, and in the Middle shale at OD-7 and OD-9.

Discussion: This species exhibits the marginal flange characteristic of the genus Marginifera.

Genus PRODUCTUS Sowerby 1814

PRODUCTUS PARVUS Meek and Worthen

Plate 2, figures 1, 2

Productus parvus MEEK AND WORTHEN, 1860, p. 450; WELLER, 1914, p. 121, pl. XVI, figs. 16-22; ELIAS, 1957, p. 500.

Dictyoclostus parvus (Meek and Worthen) SUTTON, 1938, p. 563.

Moderately concavo-convex; globular, length equals width. Greatest width just anterior to hinge line. Outline evenly rounded toward hinge line, no anterior flattening. Surface of both valves costate, eight per five mm.

Ventral exterior: Strongly convex, cardinal angle obtuse. Beak extends past hinge line. Gradual taper from umbonal area to small cardinal extremities. Spines few and randomly scattered over entire surface. Faint reticulation over posterior half of valve.

Dorsal exterior: Gently concave, costate, reticulate, cardinal process extends past hinge line. A low ridge caused by abrupt change in plane of valve encircles visceral area.

Dorsal interior: A shallow, broad sulcus extends laterally along hinge line from cardinal process. Very faint median septum extends to near mid-length. Two short broad processes extend anteriorly from cardinal process and project above shell surface. Anterior half of valve covered with low, pustulose bumps and hair-like costae. Margin of valve paralleled by low ridge created by abrupt change in plane of valve.

Occurrence: Abundant in spiculitic limestone near top of Lower Marble Falls at OD-1.

Discussion: I do not believe the faint reticulation on the ventral valve justifies assignment to the genus Dictyoclostus.

SUPERFAMILY PUNCTOSPIRACEA

FAMILY PUNCTOSPIRIFERIIDAE

Genus PUNCTOSPIRIFER North 1920

PUNCTOSPIRIFER cf. P. CAMPESTRIS (White)

Plate 3, figure 3

Spiriferina spinosa var. campestris WHITE, 1874, p. 21.

Spiriferina campestris White GIRTY, 1903, p. 396; MATHER, 1915, p. 193, pl. XIII, fig. 9-10a.

Dorsal exterior: Shell coarsely punctate, wider than long, and extremely plicate with sharp, high plications. Four plications are on one side and three on the other side of large central fold composed of a single anteriorly expanding plication. Surface of valve is covered with lamellose, overlapping layers of shell material.

Occurrence: Single valve in spiculitic limestone at top of Lower Marble Falls at OD-1.

Discussion: The genus Punctospirifer by common usage is applied to Late Paleozoic brachiopods, whereas Spiriferina has a Jurassic genotype. The former has a broad, less angular fold and sulcus.

PUNCTOSPIRIFER cf. P. KENTUCKYENSIS (Shumard)

Plate 3, figure 12

Spiriferina kentuckyensis SHUMARD, 1855, p. 203.

Punctospirifer kentuckyensis (Shumard) DUNBAR and CONDRA, 1932, p. 351, pl. XXXVIII, fig. 1-5.

Ventral exterior: Width much greater than length. Transversely convex, narrow deep sulcus with steep sides. Near mid-length of sulcus a low vertical ridge rises from center and is more pronounced at anterior margin. Four or five broad, strong, angular plications are lateral to sulcus. Surface is covered with strong punctae and appears wavy because of the coarsely lamellose structure of the valve.

Occurrence: Single specimen in lower 10 feet of Middle shale at locality OD-2.

PHYLUM MOLLUSCA

CLASS GASTROPODA

Genus EUPHEMITES Warthin 1930

EUPHEMITES SP.

Plate 4, figure 9

Planispiral, globose, with conspicuous revolving costae, and deep umbilicus with outer whorl barely overlapping inner whorl.

Occurrence: Common in Middle shale at OD-7.

Genus NATICOPSIS McCoy 1844

NATICOPSIS SP.

Plate 4, figure 11

Large, very low spired, globular. Body whorl makes up greatest bulk of shell.

Occurrence: Middle calcarenite at POC 90 and in Middle shale at OD-2.

Genus ORTHONYCHIA Hall 1843

ORTHONYCHIA PARVA (Swallow)

Plate 4, figure 7

Capulus parva SWALLOW, 1858, p. 205.

Platyceras parvum (Swallow) GIRTY, 1903, p. 461, pl. 10, figs. 1, 1a, 2, 2a.

Orthonychia parva (Swallow) KNIGHT, 1933, p. 163, pl. 25, figs. 1a-i.

Hooked or claw-like; slightly twisted but not coiled. Apex narrow, rapidly expanded and curved, crossing midline and at large angle to a line drawn through aperture. Aperture sub-oval to angular and longer than wide. Surface covered with very small transverse growth lines.

Occurrence: Abundant in Middle shale at OD-7.

Genus SPHAERODOMA Keyes 1889

SPHAERODOMA SP.

Plate 4, figure 12

Globular, anomphalous, with short acute spire with large, broadly rounded body whorl. Aperture long, narrow, with thick inductura and low thin outer lip.

Occurrence: Abundant in Upper calcarenite at locality OD-4.

Genus STRAPAROLUS Montfort 1810

Subgenus EUOMPHALOUS Sowerby 1814

STRAPAROLUS (EUOMPHALOUS) PLUMMERI Knight

Plate 4, figure 6

Straparolus (Euomphalous) plummeri KNIGHT, 1933, p. 152, pl. 22, figs. 3a-h, pl. 26, fig. 7.

Shell large, discoidal, with a very low spire. Inner whorls more rounded than outer which shows shoulders. Whorls gently and slowly expanding. Umbilicus deep. First three whorls are slightly concave or flat, lacking spire development of later whorls.

Occurrence: Rare in Upper calcarenite at OD-4.

Subgenus STRAPAROLUS

STRAPAROLUS (STRAPAROLUS) SAVAGEI Knight

Plate 4, figure 2

Straparolus (Straparolus) savagei KNIGHT, 1933, p. 149, pl. 21, figs. 1a-c; PLUMMER, 1950, pl. 17, figs. 1, 2.

Discoidal, with very low spire and deep umbilicus. First three whorls show a very low spire that is more pronounced on larger whorls. Whorls gently and broadly expanded, and showing three revolving ridges on outer side; two form outer shoulders, other in center of outer side. Surface marked with very fine sinuate, transverse growth lines.

Occurrence: Abundant in Smithwick shale at OD-3.

Genus WORTHENIA Koninck 1883

WORTHENIA TABULATA (Conrad)

Plate 4, figure 8

Turbo tabulatus CONRAD, 1835, p. 267.

Worthenia tabulata (Conrad) KNIGHT, 1941, p. 385, pl. 34, fig. 1a-c.

Low trochoform, turreted spire. A shallow broad sinus in outer lip; whorl profile shows two angulations; the upper sharp and the lower obscure. Surface covered by faint, revolving lirae on sinus. Outer extremity of whorls marked by a single row of nodes that are located at the intersection of a lirae and a transverse growth line.

Occurrence: Abundant in Middle shale at locality OD-7.

CLASS CEPHALOPODA

Genus CRAVENOCERAS Bisat 1928

CRAVENOCERAS HESPERIUM Miller

Plate 4, figures 1, 3

Glyphioceras incisum HYATT, 1893, p. 471, pl. 47, figs. 44-48.

Nuculoceras incisum (Hyatt) (Part) PLUMMER and SCOTT, 1937, p. 106 pl. 7, figs. 7-14 (not fig. 10).

Nuculoceras barnettense PLUMMER and SCOTT, 1937, p. 108, pl. 7, fig. 15-18.

Cravenoceras hesperium MILLER and FURNISH, 1940, p. 374, pl. 49, figs. 1-8.

Shell small, globular, very broad, venter nearly flat. Constrictions cross venter at approximately 90°. Umbilical shoulders are sharply rounded, completely overlapping the whorl beneath. Surface covered by transverse low, raised ridges, about nine per five mm.

The suture line has large ventral lobe with nearly parallel sides, a short ventral saddle and rounded indentation at its base, and is roundly constricted near its center. The first lateral saddle is rounded and narrower than ventral lobe, projecting from it at an angle. The first lateral lobe is broadly lanceolate with the ventral side longer. The second lateral saddle is unsymmetrical, its greatest curvature on ventral side. The second lateral lobe is small and low with a point on the umbilical shoulder.

Occurrence: Abundant in Barnett at 19 feet in Challenge Mill section.

Genus PHANEROCERAS Plummer and Scott 1937

PHANEROCERAS COMPRESSUM (Hyatt)

Plate 4, figure 4

Gastrioceras compressum HYATT, 1891, p. 355, figs. 57, 58, 59.

Phaneroceras compressum (Hyatt) PLUMMER and SCOTT, 1937, p. 191, pl. 9, fig. 4-10, pl. 11, fig. 13.

This species was identified mainly on the suture line because of the poor preservation of two specimens. The gentle rounding, slow expansion and deep umbilicus agree with the description by Plummer and Scott.

The suture has a broad ventral lobe divided anteriorly and constricted about mid-length, the anterior sides parallel. The first and second lateral saddles hastate, sides anteriorly parallel, and the constrictions rounding quickly to a point. The second lateral saddle has a steep ventral side and gently sloping dorsal side.

Occurrence: Rare in Smithwick shale at OD-10.

PHYLUM INCERTAE SEDIS

CLASS CONODONTOPHORIDAE

FAMILY PRIONIODINIDAE

Genus BACTROGNATHUS Branson and Mehl 1941

Bactrognathus BRANSON and MEHL, 1941b, p. 98.

> Elongate narrow blade-like teeth with the posterior ends sharply flexed into a lateral process; oral surface carinate; aboral surface with a pit at the union of the lateral process and the main blade, from which a deep groove extends forward and another laterally on the lateral process.

BACTROGNATHUS EXCAVATA Branson and Mehl

Plate 6, figures 29-32

Bactrognathus excavata BRANSON and MEHL, 1941b, p. 99, pl. 19, figs. 12, 13.

Thick blade, large cup-like process. Reserbles Gnathodus in general outline. Blade terminates at junction with another blade-like process that is at an angle of about 60° to blade and cup. At junction of both blades and on the obtuse side is a single large node. Surface of cup is smooth and unornamented. Anterior projection of tangential blade may be quite variable in length.

Occurrence: Abundant in Chappel at OD-12.

BACTROGNATHUS HAMATA Branson and Mehl

Plate 5, figures 13, 14

Bactrognathus hamata BRANSON and MEHL, 1941b, p. 98-99, pl. 19, fig. 5-8.

Thick, rounded blade that appears to be bent to an angle approaching

90^{o}. Oral surface coarsely carinate with large discrete denticles on anterior end. Bend in blade is just posterior to large funnel-shaped pit on aboral side. Aboral surface is marked by a deep narrow groove that becomes less evident anteriorly.

Occurrence: Common in Chappel at OD-12.

BACTROGNATHUS SCORPIODES Oden n. sp.

Plate 5, figures 31, 32

This species is much larger, more round, and thicker than others. The secondary blade appears to be a distinct bifurcation that bends around a large node on the oral side. The blade is carinate with large coarse denticles that disappear on bent part of the blade-like process.

Occurrence: Rare in Chappel at OD-12.

Genus PSEUDOPOLYGNATHUS Branson and Mehl 1934

Pseudopolygnathus BRANSON and MEHL, 1934, p. 297-298.

Lanceolate or arrow-shaped in outline, pointed toward both extremities. Blade merges with carina. Oral surface of each side of plate covered by coarse sharp ridges and deep grooves projecting from outer margin toward carina. They may converge with carina. Aboral side is marked centrally by a low ridge or keel that surrounds a pulp cavity. The size of this cavity is larger than that in the genus Polygnathus.

PSEUDOPOLYGNATHUS BICORNIS Taylor

Plate 5, figures 24, 25

Pseudopolygnathus bicornis TAYLOR, 1941, p. 52, pl. IV, fig. 55.

Oral view: Axis straight, blade thick, not distinct from carina. Plate narrow, merging with blade. One side of plate contains six large discrete transverse ridges that radiate from below carina. Third ridge is largest and separated from others by a very deep groove. Other side of plate has two large, distinct ridges at different levels; the lower one does not merge with carina. Posterior ridges converge with carina at same level.

Occurrence: Common in Chappel at base of Leonard Tank section.

PSEUDOPOLYGNATHUS FUSIFORMIS Branson and Mehl

Plate 6, figure 18, 19

Pseudopolygnathus fusiformis BRANSON and MEHL, 1934b, p. 298-299, pl. 23, figs. 1-3.

Oral view: Axis straight, blade short, thick, bearing four to six large fused denticles that increase in height anteriorly. Maximum width of long narrow plate is about midlength, and is only one-fifth of total length. Low carina, composed of faint fused nodes, extends length of plate ornamented on lateral margins by broad coarse transverse ridges.

Occurrence: Abundant in Chappel at OD-6.

PSEUDOPOLYGNATHUS PRIMA Branson and Mehl

Plate 6, figure 28

Pseudopolygnathus prima BRANSON and MEHL, 1934b, p. 298, pl. 24, figs. 24, 25; HASS, 1956, pl. 2, fig. 24; CLOUD, BARNES, and HASS, 1957, pl. 5, fig. 10.

Oral view: Axis straight, plate thick, twice as long as thick blade that bears four large denticles. Carina sharp, composed of coalesced nodes, and is bounded laterally by a discontinuous groove. Carina extends full length of plate, terminating with three distinct nodes. Plate assymmetrical with greatest width near midlength. Margins of plate marked by strong transverse ridges. Seven or eight ridges are on inner side of plate and outer side has six or seven.

Occurrence: Single specimen from Chappel float at base of Bluff Creek section.

PSEUDOPOLYGNATHUS STRICTA Taylor

Plate 6, figures 25, 26, 27

Pseudopolygnathus stricta TAYLOR, 1941, p. 51, pl. IV, figs. 53, 54.

Oral view: Plate thick, greatly expanded laterally. Blade very thick, short, orally concave, bearing two or three large denticles at anterior end. Edge of plate crenulate with distinct taper toward posterior. Carina low and discontinuous along midline. Plate covered with five or six large straight transverse ridges on each side of carina; they are separated by deep grooves. Two most anterior ridges on wider side of plate are fused near carina to form a V-shaped ridge.

Occurrence: Common in Chappel at base of Leonard Tank section.

Genus SOLENODELLA Branson 1944

Solenognathus BRANSON and MEHL, 1943b, p. 270-271.

Elictognathus COOPER, 1939, p. 386-387.

Solenodella BRANSON, 1944, p. 244.

Blade-like unit with aboral side slightly arched. Oral side strongly arched and covered with large flat denticles directed posteriorly. About one-third length from anterior the denticles are longer, creating a pre-apical elevation, and about two-thirds length from anterior is a much larger denticle, the apical. Blade anterior to apical denticle is usually straight, but may be sinuate posteriorly. Germ denticles are well developed and prominent near apical denticle. Blade flexed inward at anterior end and bears a flange or narrow shelf close to and paralleling aboral surface on both sides.

Occurrence: Common at OD-6.

Discussion: Elictognathus as defined by Cooper lacks the flange or narrow shelf along the sides paralleling the aboral surface. A single species, E. bialata, exhibits this characteristic. I believe the genus Elictognathus is an invalid genus and requires re-definition before it has priority over Solenodella.

SOLENODELLA LACERATA (Branson and Mehl)

Plate 5, figures 12, 23

Solenognathus lacerata BRANSON and MEHL, 1934b, p. 271, pl. 22, figs. 5, 6; COOPER, 1939, p. 411, pl. 44, fig. 30.

Elictognathus lacerata (Branson and Mehl) HASS, 1956, pl. 2, figs. 21, 22; CLOUD, BARNES, and HASS, 1957, pl. 5, fig. 4.

Blade straight with strong inward flexure of aboral corner. Oral edge dentate with large apical denticle and a pre-apical elevation. Denticles directed posterior with several germ denticles anterior and posterior to apical denticle. Posterior denticles, about eleven, are more rounded and narrower than anterior denticles. Sides of blade flat and smooth except for a raised ridge that parallels and is close to aboral margin.

Occurrence: Common in Chappel at base of Challenge Mill North section and at OD-6.

Discussion: Assignment of this, the type species of Solenognathus, to Elictognathus by Hass is not accompanied by a re-definition of Elictognathus, and I believe the species should be placed in the genus Solenodella.

Genus SPATHOGNATHODUS Branson and Mehl 1941

Spathodus BRANSON and MEHL, 1934, p. 46

Spathognathodus BRANSON and MEHL, 1941a, p. 172.

Straight blade-like unit with straight aboral margin and slightly curved oral margin. Sharp cup-like expansion or navel developed near mid-length on aboral side. Oral surface composed of a single row of denticles; accessory denticles may form laterally.

SPATHOGNATHODUS TRIDENTATUS (Branson)

Plate 5, figures 5, 6, 7

Spathodus tridentatus Branson BRANSON and MEHL, 1934b, p. 307-308, pl. 27, fig. 26.

Oral view: Axis straight, blade thicker in mid-region. Blade composed of 20 to 25 small denticles with rounded tips. Lobate pulp cavity on aboral surface. One side of blade possesses three large pointed denticles that are evenly spaced apart. These denticles merge with the blade at their bases and are separated from the blade at their apex.

Occurrence: Common in Chappel at OD-6.

FAMILY POLYGNATHIDAE

Genus ANCYROGNATHUS Branson and Mehl 1934

Ancyrognathus BRANSON and MEHL, 1934a, p. 240.

Plate nodose on oral side, smooth on aboral side. Plate forks at posterior end into two lobes, each bearing a median carina that bifurcates centrally. Aboral side of each lobe is bisected by a keel; the keel bifurcates posteriorly to a small pulp cavity.

ANCYROGNATHUS BIFURCATA (Ulrich and Bassler)

Plate 5, figures 17, 18

Palmatolepis bifurcata ULRICH and BASSLER, 1926, p. 50, pl. 7, figs. 16, 17.

Ancyrognathus bifurcata (Ulrich and Bassler) HASS, 1956, pl. 3, figs. 25, 26; CLOUD, BARNES, and HASS, 1957, pl. 4, fig. 9.

Oral view: Plate thick, strongly nodose with short blade containing three to four denticles, and separated from carina by a deep groove on longest side. Carina high, faintly nodose, and bifurcated about two-thirds distance from end of blade. At junction of two lobes is a faint fold best exposed on aboral side.

Occurrence: Single specimen from Chappel at base of Challenge Mill North section.

Genus PALMATOLEPIS Ulrich and Bassler 1926

Palmatolepis ULRICH and BASSLER, 1926, p. 6, 43, 44, 49; BRANSON and MEHL, 1934a, p. 233.

Form composed entirely of plate with carina-like line of nodes on oral surface; outer margins palmate and pointed at each end. Linear arrangement of nodes may be a single row or a bifurcating row with a large central azygous node. Oral surface is highly ornamented with nodes and/or pits.

PALMATOLEPIS GLABER Ulrich and Bassler

Plate 5, figures 1, 2

Palmatolepis glaber ULRICH and BASSLER, 1926, p. 51, pl. 9, figs. 18-20.

Palmatolepis glabra Ulrich and Bassler BRANSON and MEHL, 1934a, p. 233, pl. 18, figs. 9, 22, 26; HASS, 1956, pl. 3, fig. 15-17; CLOUD, BARNES, and HASS, 1957, pl. 4, fig. 10.

Oral view: Plate thick, elongate with each margin resembling a drawn-out S-shaped curve. One margin evenly sinuate; the other parallel for two-thirds length with sudden inward turn toward carina, forming a blunt shoulder. The azygous node is about one-third length from blunt shoulder, and is part of a nodose, sinuate carina that extends length of form. Margin between azygous node and blunt shoulder is folded upward. Carina becomes higher along greatest length from azygous node becoming marginal anteriorly, assuming the characteristics of a blade. Posterior to the azygous node the carina is extended by a sinuate single line of nodes that decrease in size away from node. Surface of plate on each side of carina is entirely covered by small pits.

Occurrence: Abundant in Chappel at base of Challenge Mill North section; rare in Chappel at OD-6.

PALMATOLEPIS SUPERLOBATA Branson and Mehl

Plate 5, figure 8

Palmatolepis superlobata BRANSON and MEHL, 1934a, p. 235, pl. 18, figs. 11, 21; HASS, 1956, pl. 3, fig. 4-9; CLOUD, BARNES, and HASS, 1957, pl. 4, fig. 6.

Oral view: Plate thin, very flat except for upward extension of carina posterior to azygous node. Carina curved with convex side of plate narrow; concave side has laterally projecting lobe even with the azygous node. Lateral lobe is more pointed than main lobe. Carina terminated at azygous node, increasing elevation posteriorly to blade-like proportions. A very faint ridge bisects lateral lobe. Surface covered with very low nodes and shallow pits.

Occurrence: Rare in Chappel at OD-6.

Genus POLYLOPHODONTA Branson and Mehl 1933

Polylophodonta BRANSON and MEHL, 1934a, p. 242.

Elliptical thick plate with short blade. Oral surface of plate is covered by concentric ridges or nodes paralleling the outer margin of the plate. Ridges may be smooth or nodose and nodes are common.

POLYLOPHODONTA cf. P. CONFLUENS (Ulrich and Bassler)

Plate 6, figure 4

Polygnathus confluens ULRICH and BASSLER, 1926, p. 46, pl. 7, figs. 14, 15.

Polylophodonta confluens (Ulrich and Bassler) HASS, 1956, pl. 3, fig. 10; CLOUD, BARNES, and HASS, 1957, pl. 4, fig. 12.

Oral view: Plate thick, roundly tapered toward posterior. Concentric, discontinuous rows of nodes and low ridges encircling a central row of nodes that are apparently a posterior extension of a carina.

Occurrence: Single plate in Chappel at base of Challenge Mill North section.

Genus POLYGNATHUS Hinde 1879

Polygnathus HINDE, 1879, p. 359; BRANSON and MEHL, 1933, p. 144.

Plate subsymmetrically lanceolate, with high median carina dividing plate into two lateral sub-equal areas. Carina is indicated on aboral side by narrow ridge which surrounds a small pulp cavity. Aboral side marked by fine concentric lines. Oral surface of carina bears nodes and lateral margins of plate are ornamented with nodes of nodose ridges.

POLYGNATHUS COMMUNIS Branson and Mehl

Plate 6, figures 13, 14, 15, 16

Polygnathus communis BRANSON and MEHL, 1934a, p. 293, pl. 24, figs. 1-4; HASS, 1956, pl. 2, figs. 2-5.

Oral view: Axis of blade straight, carina slightly curved. Blade has nine or 10 denticles that appear compressed laterally on anterior end. Carina has six to eight lower and wider spaced nodes, and merges with plate near posterior end. Plate thick, almost symmetrical on straight specimens with abrupt anterior taper; posterior taper is gradual and comprises three-fourths of plate. Surface of plate smooth and unornamented except for the carina.

Occurrence: Abundant in all Chappel samples.

POLYGNATHUS GRANULOSA Branson and Mehl

Plate 6, figure 8

Polygnathus granulosa BRANSON and MEHL, 1934a, p. 246, pl. 20, figs. 21, 23.

Polygnathus species A HASS, 1956, pl. 4, fig. 19.

Oral view: Plate globose, evenly rounded with a pronounced marginal indentation in outline near posterior. Carina low, broad, and formed of coalesced nodes that appear as a broad high ridge elevated above level of plate. Surface of plate covered with low but coarse randomly arranged nodes, 15 to 20 per side. Nodes on narrowest part of plate are lower and less distinct.

Occurrence: Single plate in Chappel at base of Leonard Tank section.

POLYGNATHUS INORNATA Branson

Plate 6, figure 20

Polygnathus inornata Branson BRANSON and MEHL, 1934b, p. 309, pl. 25, figs. 8, 26; HASS, 1956, pl. 2, figs. 14, 15; CLOUD, BARNES, and HASS, 1957, pl. 5, fig. 6.

This species is identified by the very deep grooves bordering the carina, a large node near the posterior end of the carina, and transverse ridges that are most prominent on the margin of the plate. The grooves are deepest on anterior, becoming shallow posteriorly. Aboral side is strongly concave longitudinally and convex transversely with a pronounced keel posterior to a small pulp cavity.

Occurrence: Single specimen in Chappel float at base of Bluff Creek section.

POLYGNATHUS NODOCOSTATA Branson and Mehl

Plate 6, figure 12

Polygnathus nodocostata BRANSON and MEHL, 1934a, p. 246-247, pl. 20, figs. 9-13, pl. 21, fig. 15.

Oral view: This species is identified by the thick plate bearing five to seven rows of nodes that parallel the carina. They maybe slightly sinuate but do not converge posteriorly.

Occurrence: Single specimen in Chappel at OD-6.

POLYGNATHUS SYMMETRICA Branson

Plate 6, figure 17

Polygnathus symmetrica Branson BRANSON and MEHL, 1934b, p. 310, pl. 25, fig. 11; BRANSON and MEHL, 1938, p. 146, pl. 33, fig. 11, pl. 34, fig. 33.

Oral view: Plate nearly symmetrical, deviation near posterior. Nodose carina level with outer extremities of plate; carina becomes less evident posteriorly, with a shallow trench on each side. Margins of plate covered with transverse ridges that disappear in the shallow groove bordering the carina. These ridges are approximately perpendicular to carina and more evident on anterior one-third of plate.

Occurrence: Rare in Chappel at base of Challenge Mill North section and at OD-6.

Genus SIPHONODELLA Branson and Mehl 1948

Siphonognathus BRANSON and MEHL, 1934b, p. 295.

Siphonodella BRANSON and MEHL, 1948, p. 528.

Arched plate, blade-like, produced anteriorly into a rostrum inclined downward from plate. Carina is low, nodose. Plate contains nodes and faint transverse ridges. Rostrum consists of highly elevated rows of nodes separated from carina by very deep grooves. Blade large, leaf-like; aboral side marked down mid-length by low keel.

SIPHONODELLA DUPLICATA (Branson and Mehl)

Plate 5, figures 28, 29, 30

Siphonognathus duplicata BRANSON and MEHL, 1934b, p. 296-297, pl. 24, figs. 16, 17.

Siphonodella duplicata (Branson and Mehl) HASS, 1956, pl. 2, figs. 6-11; CLOUD, BARNES, and HASS, 1957, pl. 5, figs. 5, 8.

Oral view: Axis curved, outer side of plate much wider than inner side. Blade thin, high, composed of 12 to 14 denticles that become more prominent anteriorly. Plate gently convex or arched. Inner side of plate covered with many small nodes. Carina low and ornamented with coalesced nodes that disappear near anterior tip of blade. Rostrum contains one ridge of coalesced nodes and one deep groove on each side of blade. These ridges are level with the surface of carina at their posterior end, but move downward anteriorly where they join blade near its aboral surface.

Occurrence: Extremely abundant in Chappel in Challenge Mill North section, and at OD-5 and OD-6. It often comprises more than half of the total number of conodonts from any single residue.

SIPHONODELLA? LOBATA (Branson and Mehl)

Plate 6, figure 24

Siphonognathus lobata BRANSON and MEHL, 1934b, p. 297, pl. 24, figs. 14, 15.

Siphonodella lobata (Branson and Mehl) CLOUD, BARNES, and HASS, 1957, pl. 5, fig. 9.

Oral view: Plate thick, lobate to leaf-shaped. Carina high, thick, composed of coalesced nodes and sinuate. Oral surface below carina marked strongly by low ridges extending from margin to carina.

Occurrence: Single specimen in Chappel at base of Challenge Mill North section.

FAMILY GNATHODONTIDAE

Genus CAVUSGNATHUS Harris and Hollingsworth 1933

Cavusgnathus HARRIS and HOLLINGSWORTH, 1933, p. 200-201; GUNNELL, 1933, p. 286; ELLISON, 1941, p. 125.

Parge forms with high platform and narrow deep trough down midline of platform, blade and carina forming one side of platform. Blade contains one larger discrete denticle anterior to platform, projecting well above surface of blade.

CAVUSGNATHUS CRISTATA Branson and Mehl

Plate 6, figures 5, 6, 7

Cavusgnathus cristata BRANSON and MEHL, 1941a, p. 177-178, pl. V, figs. 26-31; HASS, 1953, p. 77, pl. 14, figs. 12-14.

Oral view: Form elongate, high platform, blade and carina lateral and separated from platform by deep groove that becomes shallow posteriorly. Blade short, containing one large discrete denticle on anterior. Surface of carina and narrow platform marked by shallow straight grooves normal to carina. Median groove deepest at anterior end of platform and non-existent at posterior.

Occurrence: Abundant in Barnett at 19.2 and 21 feet in Challenge Mill section, at 15.5, 19.5, and 20 feet in Pecan Grove Creek (B) section, at 16 feet in Bluff Creek section. It is most abundant in glauconitic limestone in the upper five or 10 feet of the Barnett.

Genus GNATHODUS Pander 1856

Ganthodus PANDER, 1856, p. 32-34; BRANSON and MEHL, 1933, p. 144 (revised).

Jaw pieces of thin, straight or slightly curved spathodus like blade which at the posterior end is expanded into a more or less hemispherical, thin walled cup, opening aborally; the blade extending across the oral surface of the cup as a low nodose or denticulate carina that terminates on the cup or a short distance behind it; oral edge of blade sharply crenulate through the growth of laterally compressed, partly fused denticles; oral surface of cup ornamented by nodes that tend to align themselves into ridges which typically radiate from the center of the cup.

GNATHODUS BILINEATUS (Roundy) 1926

Plate 5, figures 20, 21, 22, 27

Polygnathus bilineatus ROUNDY, 1926, p. 13, pl. III, fig. 10a-c.

Polygnathus texanus ROUNDY, 1926, p. 14, pl. III, fig. 13a-b.

Gnathodus pustulosus BRANSON and MEHL, 1941a, p. 172-173, pl. 5, figs. 32-39.

Gnathodus bilineatus (Roundy) HASS, 1953, p. 78-79, pl. 14, figs. 25-29.

Oral view: This species is quite variable in size, causing a variation in node counts, proportions, and development of the carina. The distinguishing feature is the highly assymmetrical outline of the cup with the outer side almost quadrate, the inner side long and narrow; the outer side is covered with concentric bands of nodes that radiate from a point near center of carina.

Occurrence: Common in Barnett at 5, 9, 12, and 27 feet in Leonard Tank section, at 11 and 19 feet in Challenge Mill section, at 8, 13, and 15.5 feet in Pecan Grove Creek (B) section. Apparently it is restricted to the Barnett and rarely occurs above the "pellet" beds.

GNATHODUS COMMUTATUS (Branson and Mehl)

Plate 5, figures 3, 4

Spathognathodus commutatus BRANSON and MEHL, 1941b, p. 98, pl. 19, figs. 1-4; ibid. 1941a, p. 172, pl. 5, figs. 19-22.

Gnathodus inornatus HA~~LL~~SS, 1953, p. 80, pl. 14, figs. 9-11.

Spathognathodus inornatus (Branson and Mehl) CLOUD, BARNES, and HASS, 1957, pl. 5, fig. 2.

Oral view: Slightly curved blade thins orally, slightly more than twice as long as small elliptical smooth-sided cup. Carina bears 16 denticles. Over cup blade thickens aborally, merging with cup that is not ornamented. Denticles of blade more compressed than those of carina, each bearing a sharp tip. Aboral side of blade sharp, merging into sides of large funnel-shaped pulp cavity.

Occurrence: Common in Barnett at five and nine feet in Leonard Tank section, at 11 feet in Challenge Mill section, and at 15.5 feet in Pecan Grove Creek (B) section.

Discussion: *Gnathodus inornatus* does not differ from *Spathognathodus* commutatus. Assignment of this species to either Spathognathodus or Gnathodus is debatable because characteristics of both genera are exhibited. The enlargement of the pulp cavity, much larger than is usual for spathognathodids, seems more indicative of Gnathodus.

GNATHODUS MACROLOBUS (Cooper)

Plate 5, figures 19, 26, 33

Dryphenotus macrolobus COOPER, 1939, p. 386, pl. 41, figs. 48,49, pl. 42, figs. 45, 46.

Oral view: This species is identifiable because of the more pronounced expansion of the outer side of the cup, the inner side almost quadrate and the outer side semi-elliptical. The inner side bears two short rows of nodes that radiate from a central node near carina; the outer side consistently has one row of nodes radiating from the carina; this row is along anterior margin of cup. Another row of nodes may be present on the outer side; this row radiates posteriorly and is posterior to row along anterior edge.

Occurrence: Common in Chappel at base of Leonard Tank section, Challenge Mill North section and at OD-6.

Discussion: Dryphenotus is synonymous with Gnathodus in part, and is not adequately defined.

GNATHODUS MOSQUENSIS Pander

Plate 5, figures 15, 16

Gnathodus mosquensis PANDER, 1856; COOPER, 1939, p. 388, pl. 41, figs. 23-25, pl. 42, figs. 75, 76.

Polygnathus (Gnathodus) mosquensis HINDE, 1879, p. 342, pl. 9, figs. 2-4.

Gnathodus delicatus BRANSON and MEHL, 1938, p. 145, pl. 34, figs. 25-27.

Oral view: Axis straight or slightly curved, much longer than cup, blade thin, bearing 11 to 14 discrete denticles with fused bases. Carina shorter than blade and bears six to eight large nodes. Cup pointed posteriorly, slightly thinner and longer on inner side, and joins carina gradually. Outer side of cup widens abruptly at anterior end with undulating taper posteriorly. Inner side of cup bears a single row of nodes, three to eight, that are almost as high as carina and parallel to it. Outer side of cup bears varying number of randomly arranged nodes that are usually concentrated on the anterior.

Occurrence: Abundant in Chappel at base of Leonard Tank and Challenge Mill North sections, and at OD-6 and OD-12.

GNATHODUS TEXANUS Roundy

Plate 5, figures 9, 10, 11

Gnathodus texanus ROUNDY, 1926, p. 12, pl. II, figs. 7a-b, 8a-b; COOPER, 1939, p. 388, not pl. 41, figs. 26, 27; BRANSON and MEHL, 1941a, p. 173, pl. 5, figs. 23-25; HASS, 1953, p. 80, pl. 14, figs. 15-21.

Spathodus texanus (Roundy) COOPER, 1939, p. 416, pl. 42, figs. 63, 64.

Oral view: Axis nearly straight; blade narrow, bearing eight to 10 denticles that become larger and more discrete anteriorly. Blade slightly longer than cup. Cup longer on inner side of blade and expands sharply to a blunt anterior end, with nearly parallel sides whose length equals width of each side of cup. Cup tapers evenly toward posterior end of carina that bears six to eight large fused denticles. On inner side of cup near anterior end are two or three denticles lateral to carina that are fused into a stout pillarlike process. Outer side of cup may or may not bear opposing process. Outer side of cup may or may not bear opposing single denticle.

Occurrence: Rare at five and nine feet in Leonard Tank section and in Chappel at OD-12.

Genus IDIOGNATHODUS Gunnell 1931

Idiognathodus GUNNELL, 1931, p. 249; ELLISON, 1941, p. 133-134.

Platform broad, with slightly curved axis. Blade and carina bisect platform that is ornamented with large transverse ridges crossing platform posterior to carina with no indication of a central groove. Accessory nodose lobes common to anterior of platform and lateral to blade.

IDIOGNATHODUS cf. I. DELICATUS Gunnell

Plate 6, figures 1, 2, 3

Idiognathodus delicatus GUNNELL, 1931, p. 250, pl. 29, figs. 23, 24; STAUFFER and PLUMMER, 1932, p. 45, pl. 4, figs. 4, 21, 24-26; ELLISON, 1941, p. 134-135, pl. 22, figs. 31-36.

Oral view: Platform narrow, lanceolate, and curved. Surface of platform marked by six to 12 transverse grooves posterior to median carina that shows no nodes and terminates abruptly at first anterior transverse ridge. Blade thin, with nine to 10 tightly packed denticles that increase in height anteriorly. Accessory lobe on concave side is lateral to platform and is long, elliptical, narrow, and nodose. At its posterior end the adjoining ends of the transverse ridges appear to bear nodes aligned with the nodes of the lobe. The inner margin of this lobe is marked by a curved line of nodes separated from the carina by a prominent groove. Outer lobe consists of a single row of nodes separated from platform in anterior portion by a groove but joined to platform in ridge area by nodes at the end of each transverse ridge.

Occurrence: Rare near top of the Marble Falls (Upper calcarenite) at 223 and 225 feet in Post Oak Creek section, at 113 feet in Burr Tank section, and at 68 and 124 feet in Challenge Mill East section. It is associated with Polygnathodella cf P. ouachitensis, and many unidentifiable fragments.

Genus POLYGNATHODELLA Harlton 1933

Polygnathodella HARLTON, 1933, p. 15.

Form has long, narrow platform on oral surface of a large elliptical cup. Convex side of platform is composed of carina and blade. Concave side is composed of a narrow platform bearing low, transverse ridges and is separated from carina by a faint, shallow groove. Anterior end of oral surface of platform has a short deep groove between carina and platform.

POLYGNATHODELLA cf. P. OUACHITENSIS Harlton

Plate 6, figures 9, 10, 11

Polygnathodella ouachitensis HARLTON, 1933, p. 16, pl. 4, figs. 14b-c, not a.

Oral view: Plate lanceolate, axis slightly curved with convex side broader and shorter than concave side. Blade thick and as long as platform. Distinct junction of carina and blade. Surface of carina covered by low transverse ridges. Concave side of platform covered with low ridges that are offset to those of carina and separated from the carina down mid-length by a shallow groove.

Occurrence: Abundant, and invariably associated with Streptognathodus elegantulus in glauconitic limestone in upper one-third of the Barnett, and rare in the Marble Falls at 8 and 124 in Challenge Mill East, and at 105 in Burr Tank section.

Genus STREPTOGNATHODUS Stauffer and Plummer 1932

Streptognathodus STAUFFER and PLUMMER, 1932, p. 47.

Large platform with long median blade. Platform bisected at anterior end by carina that does not extend length of platform. Accessory lobes may develop on anterior end of platform and lateral to blade or carina.

STREPTOGNATHODUS cf. S. ELEGANTULUS Stauffer and Plummer

Plate 6, figures 21, 22, 23

Streptognathodus elegantulus STAUFFER and PLUMMER, 1932, p. 47-48, pl. 4, figs. 6, 7, 22, 27; ELLISON, 1941, p. 127, pl. 22, figs. 1-6, 10.

Oral view: Axis straight, platform shorter than blade. Blade is composed of seven to nine sharp, distinct denticles that merge on carina. Platform symmetrical, lobate, with margins higher than carina. Outer edge of platform denticulate and covered with elongate ridges that die out toward the carina. Carina composed of fused nodes on posterior half that disappear toward posterior. Line of carina on posterior one-third marked by row of low nodes. Blade and carina bisect platform. No accessory lobes are present on this species.

Occurrence: Common in glauconitic limestone in the upper one-third of the Barnett at 35 feet in Leonard Tank section; at 19.2 and 21 feet in

Challenge Mill section; at 20 and 24 feet in Challenge Mill North section; at 15.5, 19.5 and 20 feet in Pecan Grove Creek (B) section, and at 16 feet in Bluff Creek section. It occurs also rarely in the Marble Falls at 78 and 124 feet in Challenge Mill East section.

Discussion: Most specimens have the blade broken off but identification can still be made with only the platform. It is commonly associated with Polygnathodella cf. P. ouachitensis and Cavusgnathus cristata.

ILLUSTRATIONS OF FOSSILS

PLATES 1-6

All figured specimens are deposited with the collections of the Department of Geology, The University of Texas, Austin, Texas.

The Plates are arranged so that the productid and chonetid brachiopods are on plates 1 and 2. The remainder of the brachiopods are on plate 3. The coelenterata and mollusca are on plate 4, and the conodonts are on plates 5 and 6.

EXPLANATION OF PLATE 1

(All figures X1 unless otherwise designated)

Fig. 1, 4	Dictyoclostus cf. D. inflatus (McChesney). Ventral valve, UT12285, CMN 106.----------------------------p. 61.
2, 3, 7	Marginifera cf. M. welleri (Mather). 2, ventral exterior, UT12286a, OD-1; 3, dorsal interior, UT12287, Plmf in CMN; 7, ventral exterior, UT12286b, OD-1-------p. 67.
5, 6	Marginifera roemeri Girty. 5, dorsal interior, UT12288, OD-1; 6, ventral exterior, UT12289, CM 21-------p. 66.
8	Chonetes cf. C. granulifer Owen. Dorsal exterior, UT12290, OD-3--p. 60.
9, 11	Heteralosia cf. H. slocumi King. 9, ventral exterior, UT12291, OD-1; 11, dorsal exterior, UT12291, OD-1, p. 64.
10, 15	Dictyoclostus cf. D. morrowensis (Mather). Ventral valve, UT12292, CME 8-------------------------------p. 63.
12, 14, 18	Chonetes cf. C. choteauensis Mather. 12, ventral exterior, X2, UT12293a, CME 8; 14, ventral interior, X2, UT12294, OD-1; 18, dorsal exterior, X2, UT12293b, CME 8--p. 58.
13	Dictyoclostus cf. D. inflatus var. coloradoensis (Girty). Ventral exterior, UT12295, CMN 60----------------p. 62.
16, 17	Chonetes dominus King. 16, ventral exterior, X2, UT12296, OD-7; 17, dorsal exterior, X2, UT12296, OD-7-----p. 59.

PLATE 1

EXPLANATION OF PLATE 2

(All figures X1 unless otherwise designated)

Fig. 1, 2 — Productus parvus Meek and Worthen. 1, ventral exterior, X2, UT12297, OD-1; 2, dorsal exterior, X2, UT12297, OD-1 -- p. 69.

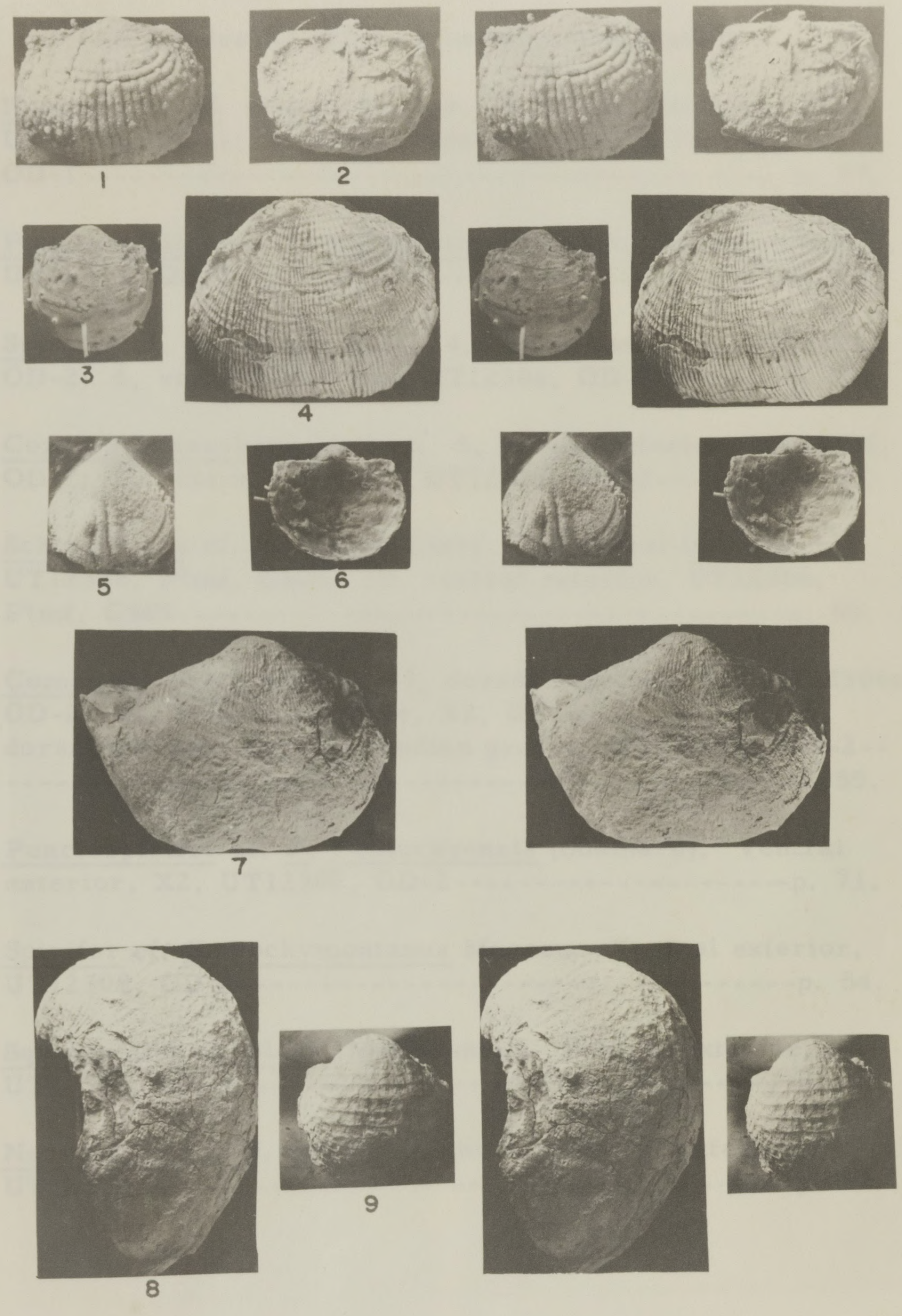
3, 6 — Horridonia cf. H. globosa (Mather). 3, ventral exterior, X2, UT12298, CM 21; 6, dorsal exterior, X2, UT12298, CM 21 -- p. 65.

4, 7, 8 — Dictyoclostus cf. D. welleri King. 4, ventral exterior, UT12299a, OD-2; 7, ventral exterior, UT12299b, OD-2; 8, lateral view, UT12299b, OD-2 ---------------- p. 64.

5 — Wellerella cf. W. osagensis (Swallow). Ventral exterior, X2, UT12300, OD-13 -------------------------- p. 51.

9 — Avonia cf. A. blairi (Miller). Ventral exterior, UT12301, PGC(B) 15.5 -------------------------------- p. 61.

PLATE 2



EXPLANATION OF PLATE 3

(All figures X1 unless otherwise designated)

Fig. 1, 2	Hustedia cf. H. miseri Mather. 1, dorsal exterior, X2, UT12302, OD-1; 2, ventral exterior, X2, UT12302, OD-1 -- p. 57.
3	Punctospirifer cf. P. campestris (White). Dorsal exterior, UT12303, OD-1 -------------------------------- p. 70.
4, 6	Spirifer cf. S. opimus Hall. 4, dorsal exterior, UT12304, OD-2; 6, ventral exterior, UT12304, OD-2 -------- p. 53.
5, 7	Composita ozarkana Mather. 5, dorsal exterior, UT12305, OD-2; 7, ventral exterior, UT12305, OD-2 -------- p. 56.
8, 10	Schizophoria cf. S. texana Girty. 8, ventral interior, UT12306, Plmf, CMN; 10, ventral exterior, UT12306, Plmf, CMN ---------------------------------- p. 50.
9, 11, 16	Composita ovata Mather. 9, dorsal exterior, X2, UT12306a, OD-2; 11, ventral exterior, X2, UT12306a, OD-2; 16, dorsal exterior showing median groove, UT12306b, OD-2-- -- p. 55.
12	Punctospirifer cf. P. kentuckyensis (Shumard). Ventral exterior, X2, UT12307, OD-2 -------------------- p. 71.
13	Spirifer cf. S. rockymontanus Marcou. Ventral exterior, UT12308, OD-2 -------------------------------- p. 54.
14	Squamularia perplexa (McChesney). Ventral exterior, UT12309, OD-7 -------------------------------- p. 54.
15	Neospirifer cf. N. goreii (Mather). Ventral exterior, UT12310, OD-1 -------------------------------- p. 52.

PLATE 3

EXPLANATION OF PLATE 4

(All figures X1 unless otherwise designated)

Fig. 1, 3 Cravenoceras hesperium Miller. 1, lateral view, UT12311a, CM 19; 3, profile view, UT12311b, CM 19---------p. 74.

2 Straparolus savagei Knight. Apical view, UT12312, OD-3---p. 73.

4 Phaneroceras compressum (Hyatt). Internal mold, UT-12313, OD-10------------------------------------p. 75.

5 Cumminsia aplata (Cummins). Corallite, UT12314, OD-3---p. 49.

6 Straparolus plummeri Knight. Apical view, UT12315, OD-4---p. 73.

7 Orthonychia parva (Swallow). Lateral view, UT12316, OD-7--p. 72.

8 Worthenia tabulata (Conrad). Lateral view, X2, UT12317, OD-7---p. 74.

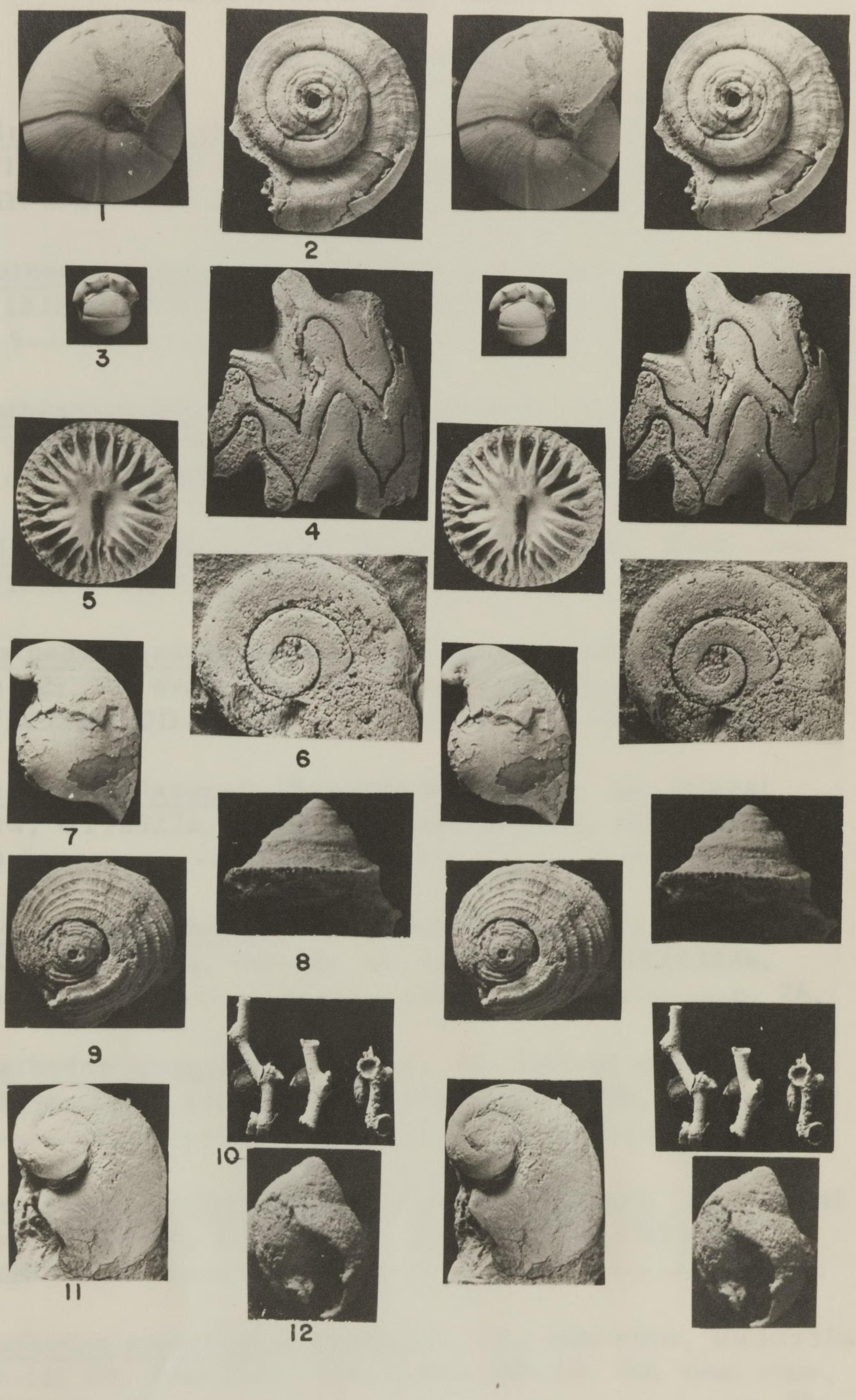
9 Euphemites sp. Lateral view, X2, UT12318, OD-7--p. 71.

10 Cladoconus cf. C. fragilis Mather. Lateral view corallum, UT12319, CM 21-----------------------------------p. 49.

11 Naticopsis sp. Apical view, steinkern, UT12320, POC 92--p. 72.

12 Sphaerodoma sp. Lateral view, X2, UT12321, OD-4--p. 72.

PLATE 4



EXPLANATION OF PLATE 5

(All figures X13)

Fig. 1, 2 Palmatolepis glaber Ulrich and Bassler. 1, plate, oral view, UT12322a, CMN 0.33; 2, plate, oral view, UT12322b, CMN 0.33-----------------------------------p. 83.

3, 4 Gnathodus commutatus (Branson and Mehl). 3, lateral view, UT12323a, PGC(B) 15.5; 4, oral view UT12323b, PGC(B) 15.5--p. 91.

5, 6, 7 Spathognathodus tridentatus (Branson). 5, lateral view, UT12324a, LT 0.33; 6, oral view UT12324b, LT 0.33, 7, oral view, UT12324c, LT 0.33----------------p. 81.

8 Palmatolepis superlobata Branson and Mehl. Oral view, UT12325, OD-6---------------------------------p. 83.

9, 10, 11 Gnathodus texanus Roundy. 9, lateral view, UT12326a, OD-12; 10, oral view, UT12326b, OD-12; 11, oral view, UT12326c, OD-12--------------------------------p. 93.

12, 23 Solenodella lacerata (Branson and Mehl). 12, lateral view, UT12327a, OD-6; 23, lateral view, UT12327b, OD-6--p. 80.

13, 14 Bactrognathus hamata Branson and Mehl. 13, lateral view, UT12328a, OD-12; 14, lateral view UT12328b, OD-12---p. 76.

15, 16 Gnathodus mosquensis Pander. 15, lateral view, UT 12329a, LT 0.33; 16, oral view, UT 12329b, LT 0.33-- --p. 92.

17, 18 Ancyrognathus bifurcata (Ulrich and Bassler). 17, aboral view, UT12330, CMN 0.33; 18, oral view, UT12330, CMN 0.33-----------------------------------p. 82.

19, 26, 33 Gnathodus macrolobus (Cooper). 19, oral view, UT12331a, OD-12; 26, oral view, UT12331b, OD-12; 33, oral view, UT12332, OD-6--------------------------------p. 92.

20-21, 27 Gnathodus bilineatus (Roundy). 20, blade fragment, UT 12333a, LT 5; 21, oral view, UT12334, PGC(B) 8; 22, oral view of plate, UT12333b, LT 5; 27, aboral view, UT12333c, LT 5-------------------------------p. 90.

Fig. 24, 25 Pseudopolygnathus bicornis Taylor. 24, oral view, UT 12335a, LT 0.33; 25, oral view, UT12335b, LT 0.33---------p. 77.

28, 29, 30 Siphonodella duplicata (Branson and Mehl). 28, aboral view, UT12336a, OD-6; 29, oral view, UT12336b, OD-6; 30, oral view, UT 12336c, OD-6-----------------------------p. 88.

31, 32 Bactrognathus scorpiodes Oden. 31, aboral view, UT12337, OD-12; 32, oral view, UT 12337, OD-12-------------p. 77.

PLATE 5


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33

EXPLANATION OF PLATE 6

(All figures X13)

Fig. 1, 2, 3 Idiognathodus cf. I. delicatus Gunnell. 1, oral view, UT12338a, CME 124; 2, oral view, UT12338b, CME 124; 3, oral view, UT12338c, CME 124----------------------------------p. 94.

4 Polylophodonta cf. P. confluens (Ulrich and Bassler). Oral view of fragment of plate, UT12339, CMN 0.33------p. 84.

5, 6, 7 Cavusgnathus cristata Branson and Mehl. 5, lateral view, UT12340a, PGC(B) 19.5; 6, oral view, UT12340b, PGC(B) 19.5; 7, oral view, UT12340c, PGC(B) 19.5--------p. 89.

8 Polygnathus granulosa Branson and Mehl. Oral view of plate fragment, UT12341, LT 0.33------------------------p. 85.

9, 10, 11 Polygnathodella cf. P. ouachitensis Harlton. 9, lateral view, UT12342a, PGC(B) 15.5; 10, oral view, UT12342b, PGC(B) 15.5; 11, oral view, UT12342c, PGC(B) 15.5-------p. 95.

12 Polygnathus nodocostata Branson and Mehl. Oral view of plate fragment, UT12343, OD-6-------------------------p. 87.

13-16 Polygnathus communis Branson and Mehl. 13, oral view, UT12344a, LT 0.33; 14, lateral view, UT12344b, LT 0.33; 15, oral view, UT12344c, LT 0.33; 16, aboral view, UT12344d, LT 0.33-----------------------------p. 85.

17 Polygnathus symmetrica Branson. Oral view, UT12345, CMN 0.33---------------------------------------p. 87.

18, 19 Pseudopolygnathus fusiformis Branson and Mehl. 18, aboral view, UT12346, OD-6; 19, oral view, UT12346, OD-6--p. 78.

20 Polygnathus inornata Branson. Oral view, UT12347, BC 0, float--p. 86.

21-23 Streptognathodus cf. S. elegantulus Stauffer and Plummer. 21, oral view, UT12348a, PGC(B) 15.5; 22, lateral view, UT12348b, PGC(B) 15.5; 23, aboral view, UT12348c, PGC(B) 15.5---p. 96.

24 Siphonodella? lobata (Branson and Mehl). Fragment of plate, UT12349, CMN 0.33--------------------------------p. 88.

Fig. 25-27 Pseudopolygnathus stricta Taylor. 25, aboral view, UT12350a, LT 0.33; 26, lateral view, UT12350b, Lt 0.33; 27, oral view, UT12350c, LT 0.33-------------------------p. 79.

28 Pseudopolygnathus prima Branson and Mehl. Oral view, UT12351, BC 0 (float)-----------------------------p. 78.

29-32 Bactrognathus excavata Branson and Mehl. 29, oral view, UT12352a, OD-12; 30, oral view, UT12352b, OD-12; 31, oral view, UT12352c, OD-12; 32 oral view, UT12352d, OD-12--p. 76.

PLATE 6


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32

REFERENCES

Abilene and Fort Worth Geological Societies, 1957, Joint field trip guidebook, study of Lower Pennsylvanian and Mississippian rocks of the northeast Llano Uplift: Fort Worth, p. 1-52.

Bassler, R. S., 1937, The Paleozoic rugose coral family Paleocyclidae: Jour. Paleontology, v. 11, p. 189-201, pl. 30-32.

Bogardus, E. H., 1957, Lower Pennsylvanian of the Richland Springs area, San Saba County, Texas: unpublished M.A. thesis, The University of Texas, 158 p.

Branson, E. B., and Mehl, M. G., 1933, A study of Hinde's types of conodonts in the British Museum: Univ. Missouri Studies, v. 8, n. 2, p. 77-167, pl. 5-12.

____________________, 1934a, Conodont studies no. 3, Conodonts from the Grassy Creek shale of Missouri: Univ. Missouri Studies, v. 8, n. 3, p. 171-259, pl. 13-21.

____________________, 1934b, Conodont studies no. 4, Conodonts from the Bushberg sandstone and equivalent formations of Missouri: Univ. Missouri Studies, v. 8, n. 4, p. 265-300, pl. 22-24.

____________________, 1938, Conodonts from the lower Mississippian of Missouri, pt. 2, by E. B. Branson, et al.: Univ. Missouri Studies, v. 13, n. 4, p. 128-148, pl. 33-34.

____________________, 1941a, Caney conodonts of upper Mississippian age: Bull. Denison Univ. Sci. Lab., v. 35, p. 167-178, pl. 5.

____________________, 1941b, New and little known Carboniferous conodont genera: Jour. Paleontology, v. 15, n. 2, p. 97-106, pl. 19.

____________________, 1944, Conodonts, in Index fossils of North America, by H. W. Shimer and R. R. Shrock: New York, John Wiley & Sons, Inc., p. 235-246, pl. 93-94.

Bridge, Josiah, and Girty, G. H., 1937, A re-description of Ferdinand Roemer's Paleozoic types from Texas: U. S. Geol. Survey Prof. Paper 186-M, p. 239-271, pl. 67-70.

Cheney, M. G., 1940, Geology of north central Texas: Amer. Assoc. Petroleum Geologists Bull., v. 24, n. 1, p. 65-118.

Cheney, M. G., 1945, Classification of Mississippian and Pennsylvanian rocks of North America: Sub-committee on the Carboniferous, Amer. Assoc. Petroleum Geologists, v. 29, n. 2, p. 69-125.

__________, 1947, Pennsylvanian classification and correlation problems in north central Texas: Jour. Geology, v. 55, n. 3, p. 207.

Cloud, P. E., 1955, Physical limits of glauconite formation: Amer. Assoc. Petroleum Geologists Bull., v. 39, p. 484-492.

__________, and Barnes, V. E., 1948, The Ellenburger group of central Texas: Univ. Texas Publ. 4621, p. 42-60.

__________, Barnes, V. E., and Hass, W. H., 1957, Devonian-Mississippian transition in central Texas: Geol. Soc. America Bull., v. 68, n. 7, p. 807-816, pl. 4, 5.

Cooper, C. L., 1939, Conodonts from a Bushberg-Hannibal horizon in Oklahoma: Jour. Paleontology, v. 13, n. 4, p. 379-422.

Cummins, W. F., 1891, Report on the geology of northwestern Texas: Texas Geol. Survey, 1st Ann. Rept., p. 357-552.

Dumble, E. T., 1890, Report of the State Geologists: Texas Geol. Survey, 1st Ann. Rept., p. xvii-xc.

Dunbar, C. O., and Condra, G. E., 1932, Brachiopoda of the Pennsylvanian System in Nebraska: Nebraska Geol. Survey Bull. 5, p. 1-374.

Elias, M. K., 1957, Late Mississippian fauna from the Redoak Hollow formation of southern Oklahoma: pt. II, Brachiopoda: Jour. Paleontology, v. 31, n. 3, p. 487-527, pl. 53-58.

Ellison, S. P., 1941, Revision of the Pennsylvanian conodonts: Jour. Paleontology, v. 15, n. 2, p. 107-143, pl. 20-23.

__________, 1946, Conodonts as Paleozoic guide fossils: Amer. Assoc. Petroleum Geologists Bull., v. 30, p. 93-110, fig. 1-3.

Fay, R. O., 1952, Catalogue of conodonts: Univ. Kansas, Art. 3, 206 p.

Flawn, P. T., 1956, Basement rocks of Texas and southeast New Mexico: Univ. Texas Publ. 5605, p. 59.

Folk, R. L., 1957, Petrology of sedimentary rocks: Austin, Texas, Hemphill Book Store, p. M-1--P-14.

Girty, G. H., 1911, The fauna of the Moorefield shale of Arkansas: U. S. Geol. Survey Bull. 439, p. 1-145, pl. XV.

__________, 1915, The fauna of the Batesville sandstone of northern Arkansas: U. S. Geol. Survey Bull. 593, p. 1-167, pl. I-XI.

__________, 1919, The Bend formation and its correlation: Amer. Assoc. Petroleum Geologists Bull., v. 3, p. 71-81.

__________, 1927, Descriptions of new species of Carboniferous and Triassic fossils; appendix to Geography, geology, and mineral resources of part of southeastern Idaho, by G. R. Mansfield: U. S. Geol. Survey Prof. Paper 152, p. 411-446, pl. 22-25, 27, 29.

__________, and Moore, R. C., 1919, Age of the Bend Series: Amer. Assoc. Petroleum Geologists Bull., v. 3, p. ~~415~~-420.
418

Goldman, M. I., 1921, Lithologic subsurface correlation in the "Bend Series" of north-central Texas: U. S. Geol. Survey Prof. Paper, 129-A, p. 1-22.

Gunnell, F. H., 1931, Conodonts from the Fort Scott limestone of Missouri: Jour. Paleontology, v. 5, n. 3, p. 244-253, pl. 29.

__________, 1933, Conodonts and fish remains from the Cherokee, Kansas City, and Wobaunsee groups of Missouri and Kansas: Jour. Paleontology, v. 7, n. 3, p. 261-297, pl. 31-33.

Hall, James, and Whitney, J. D., 1858, Geology of Iowa: v. l, pt. II, p. 711, pl. XXVIII, fig. 1a-b.

Harlton, B. H., 1933, Micropaleontology of the Pennsylvanian Johns Valley shale of the Ouachita Mountains, Oklahoma, and its relationship to the Mississippian Caney shale: Jour. Paleontology, v. 7, n. 1, p. 3-29, pl. 1-7.

__________, 1934, Carboniferous stratigraphy of the Ouachitas with special study of the Bendian: Amer. Assoc. Petroleum Geologists Bull., v. 18, n. 8, p. 1018-1049.

Harris, R. W., and Hollingsworth, R. V., 1933, New Pennsylvanian conodonts from Oklahoma: Am. Jour. Sci., ser. 5, v. 25, n. 147, p. 193-204, pl. 1.

Hass, W. H., 1953, Conodonts of the Barnett formation of Texas: U. S. Geol. Survey Prof. Paper 243-F, p. 69-94, pl. 14-16.

Hass, W. H., 1956, Age and correlation of the Chattanooga shale and the Maury formation: U. S. Geol. Survey Prof. Paper 286, p. 1-45, pl. 2-5.

Hill, R. T., 1889, A portion of the geologic story of the Colorado River of Texas: American Geol. v. 3, p. 287-299.

Hinde, G. J., 1879, On conodonts from the Chazy and Cincinnati groups of the Cambro-Silurian, and from the Hamilton and Genesee shale divisions of the Devonian, in Canada and the U. S.: Quart. Jour. Geol. Soc. London, v. 35, pt. 3, n. 139, p. 351-369, pl. 15-17.

Hyatt, Alpheus, 1891, Carboniferous cephalopods: Texas Geol. Survey, 2nd Ann. Rept. p. 327-356, figs. 23-59.

__________, 1893, Carboniferous cephalopods: Texas Geol. Survey, 4th Ann. Rept., 2nd paper, p. 379-474.

King, R. H., 1938, New Chonetidae and Productidae from Pennsylvanian and Permian strata of north central Texas: Jour. Paleontology, v. 12, n. 3, p. 257-279, pl. 36-39.

Knight, J. B., 1933, Gastropods of the St. Louis, Missouri, Pennsylvanian outlier, VII: the Euomphalidae and Platyceratidae: Jour. Paleontology, v. 8, n. 2, p. 134-166, pl. 20-26.

__________, 1941, Paleozoic gastropod genotypes: Geol. Soc. America Spec. Paper No. 32, 505 p., pl. 1-96.

Marcou, Jules, 1858, Geology of North America: p. 50, pl. VII, fig. 4c, d, e.

Mather, K. F., 1915, The fauna of the Morrow group of Arkansas and Oklahoma: Bull. Denn. Univ. Sci. Lab., v. XVIII, art. 3, p. 59-284, pl. I-XVI.

Meek, F. B., and Worthen, A. H., 1860, Descriptions of new Carboniferous fossils from Illinois and other western states: Proc. Acad. Nat. Sci. Phila., p. 450.

Miller, S. A., 1891, Advance sheets: 18th Rept., Geol. Survey Indiana, p. 79, pl. 13, fig. 16.

Miller, A. K., and Furnish, W. M., 1940, Studies of Carboniferous ammonoids, parts 1-4: Jour. Paleontology, v. 14, p. 356-377, pl. 45-49.

Miller, A. K., and Youngquist, Walter, 1949, The cephalopod fauna of the Mississippian Barnett formation of central Texas: Jour. Paleontology, v. 22, n. 6, p. 649-671, pl. 94-100.

Moore, R. C., et al., 1944, Correlation of Pennsylvanian formations: Geol. Soc. America Bull., v. 55, p. 706.

Moore, R. C., and Jeffords, R. M., 1945, Descriptions of lower Pennsylvanian corals from Texas and adjacent states: Univ. Texas Publ. 4401, p. 77-209, pl. 1-14.

____________, and Thompson, M. L., 1949, Main divisions of the Pennsylvanian Period and System: Amer. Assoc. Petroleum Geologists Bull., v. 33, n. 3, p. 275-302.

Morningstar, Helen, 1922, The Pottsville fauna of Ohio: Geol. Survey Ohio Bull. 25, p. 1-312, pl. I-XVI.

McChesney, J. H., 1860, Descriptions of new species of fossils from the Paleozoic rocks of the western states: Extract from Trans. Chicago Acad. Sci., v. I, p. 1-76.

Owen, D. D., 1853, Remarks on the geology of Wisconsin, Iowa, and Minnesota: Acad. Nat. Sci. Phila., tab. 5, fig. 12-a-d.

Paige, Sidney, 1912, Geological atlas of the United States, Llano-Burnet folio: U. S. Geol. Survey Folio n. 183, p. 8.

Pander, C. H., 1856, Monographie der fossilen Fische des silurischen Systems der russischbaltischen Gouvernements: K. Akad. d. Wiss. St. Petersburg, p. 1-91, pl. 1-9.

Plummer, F. B., 1945, Stratigraphy of the lower Pennsylvanian coral-bearing strata of Texas: Univ. Texas Publ. 4401, p. 63-76.

____________, 1947, Summary of classification of the Pennsylvanian formations of Texas, with special reference to the lower Pennsylvanian of the Llano region: Jour. Geol., v. 55, p. 193.

____________, 1950, The Carboniferous rocks of the Llano region of central Texas: Univ. Texas Publ. 4329, 170 p.

____________, and Moore, R. C., 1922, Pennsylvanian strata of north central Texas: Univ. Texas Publ. 2132, p. 24.

____________, and Scott, Gayle, 1937, Upper Paleozoic ammonites in Texas: Univ. Texas Publ. 3701, pt. 1, p. 411, pl. 1-41.

Roundy, P. V., Girty, G. H., and Goldman, M. I., 1926, Mississippian formations of San Saba County, Texas: U. S. Geol. Survey Prof. Paper 146, 63 p., pl. I-IV.

Sellards, E. H., 1933, The pre-Paleozoic and Paleozoic Systems in Texas, in The geology of Texas: Univ. Texas Publ. 3232, v. 1, p. 15-231.

Shumard, B. F., 1855, Geologic section on the Mississippi River from St. Louis to Commerce: Mississippi Geol. Survey Ann. Rept. II, p. 203.

Spivey, R. C., and Roberts, T. G., 1946, Lower Pennsylvanian terminology in central Texas: Amer. Assoc. Petroleum Geologists, v. 30, n. 2, p. 181-186.

Stauffer, C. R., and Plummer, H. J., 1932, Texas Pennsylvanian conodonts and their stratigraphic relationships: Univ. Texas Publ. 3201, p. 13-50, pl. I-IV.

Sutton, A. H., 1938, Taxonomy of Mississippian Productidae: Jour. Paleontology, v. 12, n. 6, p. 537-569, pl. 62-66.

Swallow, G. C., 1855, Valley of the Verdegris: Trans. St. Louis Acad. Sci., v. 1, p. 205.

Taylor, Louis, 1941, The conodonts and age of the Welden limestone: M.A. Thesis, Univ. Missouri, 67 p., pl. IV.

Thompson, M. L., 1942, New genera of Pennsylvanian fusulinids: Amer. Jour. Sci., v. 240, n. 6, p. 403-420.

________________, 1947, Stratigraphy and fusulinids of pre-Desmoinesian Pennsylvanian rocks, Llano Uplift, Texas: Jour. Paleontology, v. 21, p. 147-164.

Udden, J. A., Baker, C. L., and Böse, Emil, 1916, Review of the geology of Texas: Univ. Texas Publ. 44, 64 p., 10 figs., 6 pls.

Ulrich, E. O., and Bassler, R. S., 1926, A classification of the toothlike fossils, conodonts, with descriptions of American Devonian and Mississippian species: U. S. Nat. Mus. Proc., v. 68, art. 12, n. 2613, p. 1-63, pl. 1-11.

Weller, J. M., et al, 1948, Correlation of the Mississippian formations of North America: Geol. Soc. America Bull., v. 59, p. 91-196.

Weller, Stuart, 1914, The Mississippian Brachiopoda of the Mississippi Valley Basin: Illinois State Geol. Survey Monograph I, vol. 1, 508 p., vol. 2, LXXXIII pl.

White, C. A., 1874, Preliminary report upon invertebrate fossils collected by expeditions of 1871, 1872, 1873, with descriptions of new species: U. S. Geol. and Geog. Survey W. 100th Meridian (Wheeler Survey), p. 21.

APPENDIX A

MEASURED SECTIONS

Measured sections are arranged alphabetically; their positions are plotted on the map (Plate 1, in pocket), and a panel diagram (Plate 2, in pocket) was constructed with the base of each section approximately in its correct geographic position. Directions for offset in sections are to be read going up-section. Only two sections, Post Oak Creek and Pecan Grove Creek, were painted at 5-foot intervals; they are described petrographically. Rock descriptions were made using a binocular microscope, describing wet etched surfaces. Where applicable, petrographic names are included in the measured sections.

BLUFF CREEK SECTION (BC)

This section is described in the Abilene and Fort Worth Geological Society Guidebook (1957, p. 32-38). The base of the section is directly across the San Saba River from Lemons Camp. Thicknesses and descriptions were used because of the close proximity to the Post Oak Creek section.

Description	Unit Thickness	Feet Above Base
MARBLE FALLS FORMATION	242	18-260
Upper Marble Falls member	102	158-260
Middle Marble Falls member	83	75-158
Middle shale	33	125-158
Middle calcarenite	50	75-125
Lower Marble Falls member	57	18-75
BARNETT FORMATION	18	0-18

BURR TANK SECTION (BT)

The base of this section is 1800 feet southwest of Burr Tank on the Ellenburger at the foot of the slope. The section was measured straight up the slope in a north by northwest direction. Totaling 121 feet, it contains 15 feet of Barnett. The top of the section probably is within 10 feet of the base of the Smithwick that is present on the dip slope.

Description	Unit Thickness	Feet Above Base
SMITHWICK FORMATION: not measured		
8. Shale - olive green to light yellow-brown, badly weathered.		
MARBLE FALLS FORMATION: 116 feet measured		
Upper Marble Falls member: 36 feet measured		
Upper calcarenite: 13 feet measured		
7. Sandy limestone - light gray to yellow-brown fine grained and microcrystalline; thinly bedded. Contains many rounded quartz sand grains and chert gravel. At 113 feet, light yellow-brown, fine grained, sandy limestone contains many quartz sand grains, chert pebbles, and fusulinids in sparry calcite matrix. At 111 feet, light gray fine grained and microcrystalline limestone with less quartz sand grains and few chert pebbles. Thin chert lenses common.	13	108-121
BT 113, Idiognathodus cf. I. delicatus		
Upper spiculite: 23 feet measured		
6. Spiculitic limestone - light yellow-gray to orange pink microcrystalline spiculitic limestone, few thin beds of light gray allochemical limestone in upper 3 feet.	23	85-108

Description	Unit Thickness	Feet Above Base
Bedding even, 6 inches to 2 feet thick. At 105 feet, very light yellow-gray fine grained limestone containing few quartz sand grains, many intraclasts, much bioclastic material, and rare fusulinids. At 103 feet, orange pink microcrystalline limestone with many spicules and flakes of limonite. At 85 feet gray-yellow microcrystalline silty spiculitic limestone.		
BT 105, Polygnathodella cf. P. ouachitensis		
Middle Marble Falls member: 29 feet measured		
Middle shale: 29 feet measured		
5. Shale - covered recessive slope, thin shaly spiculitic pale olive-brown limestone beds from 79 to 85 feet. Slope covered with float from overlying member. Weathering reduces the limestone beds to blocky rounded boulders, their surfaces covered with vermiform markings.	29	56-85
Lower Marble Falls member: 41 feet measured		
4. Limestone - dark olive gray evenly bedded microcrystalline. Irregularly mottled appearance. At 49 feet, medium gray-brown microcrystalline spiculitic limestone.	7	49-56
3. Limestone - dark gray to black, microcrystalline. Black to dark gray chert nodules common. Bedding nodular, varies from 2 inches to 1.5 feet thick. Jointed chert and limestone from 15 to 24 feet, joints filled with white chert. Rock at 24 feet medium olive gray microcrystalline limestone containing many spicules and much black organic matter.	34	15-49
BARNETT FORMATION: 15 feet measured		
2. Shale and interbedded limestone - recessive slope covered with dark gray and	15	0-15

Description	Unit Thickness	Feet Above Base
black limestone and chert. Many broken gray-brown petroliferous concretions. At 7 feet, light yellow gray microcrystalline limestone. Acetic acid residues contain ostracods and fish teeth.		
ELLENBURGER GROUP: not measured		
1. Limestone - white to light gray sublithographic, containing light pink-gray chert nodules.		

CHALLENGE MILL SECTION (CM)

This section is 2000 feet due north of Challenge Mill. It was measured along the south side of a small creek. The section is entirely within the Barnett formation, and neither the upper nor lower boundary is exposed.

Description	Unit Thickness	Feet Above Base
BARNETT FORMATION: 21 feet measured		
6. Limestone - dark brown microcrystalline, containing silicified brachiopods and corals, glauconite, rare quartz sand grains, phosphate pellets and fish teeth. Bedding distinct, uneven. Weathered surfaces expose many crinoid columnals and corals.	0.5	20.5-21
CM 21, _Cavusgnathus cristata_ _Polygnathodella_ cf. _P. ouachitensis_ _Streptognathodus_ cf. _S. elegantulus_ _Marginifera roemeri_ _Cladoconus_ cf. _C. fragilis_ _Horridonia globosa_		
5. Shale - light brown, containing glauconite, phosphatic material and crinoid columnals.	1	19.5-20.5
4. Limestone - medium gray, glauconitic, soft, containing brachiopods, quartz sand grains, phosphatic pellets, fish teeth and bone fragments. This bed compares lithically with CMN 20 and 24.	0.5	19.0-19.5
CM 19.5, _Streptognathodus_ cf. _S. elegantulus_ _Cavusgnathus cristata_ _Marginifera_ cf. _M. welleri_ _Marginifera roemeri_		
3. Glauconitic limestone - medium brown to dark red-brown glauconitic, microcrystalline, containing many goniatitic	0.8	18.2-19.0

Description		Unit Thickness	Feet Above Base
	ammonoids. CM 19, Cravenoceras hysperium Gnathodus bilineatus		
2.	Shale - light brown badly weathered, containing thin, two to three inch, unevenly bedded, silty dark brown limestone beds.	7.2	11.0-18.2
1.	Shale - light yellow-brown, pale blue-gray and red-brown, containing dark brown petroliferous concretions. CM 11, Gnathodus bilineatus Gnathodus commutatus	11	0.0-11.0

CHALLENGE MILL EAST SECTION (CME)

This section is 4900 feet airline distance due east of Challenge Mill. It was measured in a south direction along the east side of a small creek. The section contains 124 feet of Marble Falls; no Barnett was exposed.

Description	Unit Thickness	Feet Above Base
MARBLE FALLS FORMATION: 124 feet measured		
Upper Marble Falls member: 70 feet measured		
Upper calcarenite: 40 feet measured		
6. Limestone - light gray fine grained and microcrystalline. Bedding thin, undulose. Gray chert nodules and thin beds common. Limestone contains intraclasts and many elongate tubular hollow bodies (algae?). At 124 feet limestone contains small grains of glauconite.	40	84-124
CME 124, Idiognathodus cf. I. delicatus Polygnathodella cf. P. ouachitensis Streptognathodus cf. S. elegantulus		
CME 96, Chaetetes sp.		
Upper spiculite: 30 feet measured		
5. Spiculitic cherty limestone - light yellow-brown to orange-brown microcrystalline, that weathers to a rusty brown color. Bedding distinct, even, thinning upward from 1 to 2 feet to 6 to 8 inches. Lower 3 feet interbedded shale and spiculitic limestone. Beds of gray-brown chert common from 74 to 77 feet.	30	54-84
CME 78, Streptognathodus cf. S. elegantulus Idiognathodus cf. I. delicatus		

	Description	Unit Thickness	Feet Above Base
	Middle Marble Falls member: 29 feet measured		
	Middle shale: 29 feet measured		
4.	Shale - dark brown to black, weathers to a light yellow-brown color. At 38 feet, large black limestone concretions.	29	25-29
	Lower Marble Falls member: 25 feet measured		
3.	Dark limestone and shale - black microcrystalline. Beds 6 to 8 inches thick, interbedded very evenly with shale. Limestone contains many small brachiopods. Shale intervals increase in thickness upward.	11	14-25
2.	Limestone - black microcrystalline. Beds 6 to 8 inches thick, even.	6	8-14
1.	Dark cherty limestone - black microcrystalline, containing black amoeboid chert nodules. Bedding nodular, obscure, about 2 feet thick, and badly jointed.	8	0-8

CME 8, Marginifera cf. M. roemeri
Chonetes cf. C. choteauensis
Composita cf. C. ozarkana
Dictyoclostus cf. D. morrowensis
Linoproductus sp.
Polygnathodella cf. P. ouachitensis
Squamularia perplexa

CHALLENGE MILL NORTH SECTION (CMN)

This section is located 2000 feet northwest of Challenge Mill and is 800 feet southeast of a cattle guard 1.2 miles north of Hackberry Mill on the Richland Springs road. The section is divided by a fault; both parts were measured northward paralleling the fault. The lower 62 feet are on the west side of the fault and the upper 57 feet are on the east side of the fault. Loss of section caused by crossing the fault is estimated not to exceed 5 feet. The base of the section is 10 feet north of a fence and 50 feet west of a small creek. The section contains 84 feet of Marble Falls, 35 feet of Barnett and 0.33 feet of Chappel.

Description	Unit Thickness	Feet Above Base
MARBLE FALLS FORMATION: 84 feet measured		
Upper Marble Falls member: 23 feet measured		
Upper spiculite: 23 feet measured		
8. Cherty limestone - light gray to orange-pink microcrystalline. Beds thin, 6 inches to 1 foot, very even. Small nodules and thin beds of brown-gray chert are common. Lower 3 feet interbedded with shale.	23	96-119
CMN 106, <u>Dictyoclostus</u> cf. <u>D</u>. <u>inflatus</u>		
Middle Marble Falls member: 29 feet measured		
Middle shale - 10 feet measured		
7. Shale? - recessive slope covered with float from overlying unit.	10	86-96
Middle calcarenite: 19 feet measured		
6. Algal and bioclastic limestone - light	13	73-86

Description	Unit Thickness	Feet Above Base
yellow-brown to pink-brown fine grained and sublithographic limestone. Bedding thin and undulose. Upper surface nodular, uneven with numerous Chaetetes sp. At 83 feet light yellow-brown microcrystalline to sublithographic limestone containing intraclasts, ovoid bodies (algae?) and random patches of sparry calcite. At 74 feet light brown-gray sublithographic limestone containing many large angular streaks of sparry calcite. The rock has a brecciated appearance because of the large amount and angularity of the sparry calcite.		
5. Bioclastic limestone - light gray to pink-brown fine grained limestone with numerous sparry calcite streaks. Bedding thin, undulose, obscure. Weathered surfaces show many crinoid columnals and silicified cup corals. At 70 feet, light brown microcrystalline allochemical limestone containing many patches of sparry calcite, intraclasts, and small elongate ovoid bodies. At 67 feet, light gray, fine grained limestone containing many ellipsoidal and tubular hollow bodies (algae?).	6	67-73
OFFSET across fault.		
. Lower Marble Falls member: 28 feet measured		
4. Limestone - olive gray to dark gray microcrystalline, containing few spicules and much organic matter. Interval poorly exposed, but probably thin bedded. Limestone weathers to small rounded blocks.	14	48-62
3. Dark cherty limestone - medium gray and black, microcrystalline. Contains dark gray and black chert nodules. Bedding very uneven. At 38 feet, medium yellow-gray to dark gray microcrystalline limestone.	14	34-48

Description	Unit Thickness	Feet Above Base
CMN 60, Dictyoclostus cf. D. inflatus var. coloradoensis Dictyoclostus cf. D. morrowensis		
Fossils collected from the Lower Marble Falls 20 feet east of the line of section, in a block dragged down by the fault. Marginifera cf. M. welleri Marginifera roemeri Schizophoria cf. S. texana Linoproductus sp. Chonetes cf. C. choteauensis		
BARNETT FORMATION: 34 feet measured		
2. Shale and limestone - recessive slope covered with black limestone and chert float. Petroliferous concretions abundant. At 24 and 20 feet, dark brown, fine grained and microcrystalline phosphatic and glauconitic.	33.66	0.33-34.0
CMN 24, Streptognathodus cf. S. elegantulus Polygnathodella cf. P. ouachitensis		
CMN 20, Streptognathodus cf. S. elegantulus		
CHAPPEL FORMATION: 0.33 feet measured		
1. Limestone - light gray fine grained and microcrystalline, strongly limonitic, contains few frosted quartz sand grains, crinoid columnals and many conodonts. Ancyrognathus bifurcata Gnathodus macrolobus Gnathodus mosquensis Palmatolepis glaber Polygnathus communis Polygnathus symmetrica Siphonodella duplicata Siphonodella lobata Solenodella lacerata	0.33	0.0-0.33
ELLENBURGER GROUP: not measured		

INK HOLE SECTION (IH)

This section is 2500 feet airline distance due west of the mouth of Post Oak Creek, but on the south side of the San Saba River. The section is offset across a fault. The lower 120 feet continues westward from the fault, and the upper 120 feet continues eastward from the base of the section. Offset across the fault was made on the top of the Middle shale and is believed to be accurate within 10 feet.

The section is not in the Leonard Ranch area, but was utilized because of the close control offered by the three large sections, in close proximity, in the Lemons Camp vicinity.

Description	Unit Thickness	Feet Above Base
MARBLE FALLS FORMATION: 240 feet measured		
Upper Marble Falls member: 120 feet measured		
Upper calcarenite: 15 feet measured		
9. Limestone - buff, coarsely crinoidal bioclastic, fine and microcrystalline. Bedding obscure, irregular; large algal masses. At 238.5, white and buff, crinoids, fusulinids, fine grained and microcrystalline, abundant fine bioclastics; at 238, light brown spiculitic chert and light brown to buff very homogeneous microcrystalline limestone. Rare light brown and gray chert nodules. Rounded pebbles of dark chert at base.	15	225-240
Upper spiculite: 105 feet measured		
8. Limestone - gray-brown and yellow-brown, microcrystalline, spiculitic; contains minor allochemical, crinoidal,	45	180-225

Description	Unit Thickness	Feet Above Base
fine grained limestone beds. At 225 buff, microcrystalline, finely bioclastic, containing black limestone pebbles; at 221, gray-brown, finely bioclastic, microcrystalline; at 209, light yellow-brown spiculitic, microcrystalline; at 202, very light gray-brown microcrystalline; at 199, 191, light yellow-brown, finely bioclastic, silicified, spiculitic, microcrystalline; at 181, medium gray-brown bioclastic spiculitic, microcrystalline. Rare nodular chert.		
7. Limestone - light yellow-brown to gray-brown, spiculitic, microcrystalline. Bedding thin, 6 inches to 10 inches, very even. Minor shale partings; little nodular chert. At 178, dark gray, spiculitic, microcrystalline; at 169, light yellow-brown, spiculitic, very homogeneous; at 153, yellow-brown, spiculitic, microcrystalline; at 133, dark gray, slumped, microcrystalline.	60	120-180
OFFSET. Return to base of section and continue eastward downstream.		
Middle Marble Falls member: 46 feet measured		
Middle shale: 33 feet measured		
6. Limestone and shale - interbedded gray-brown shale and yellow-gray, spiculitic, shaly, microcrystalline limestone.	27	93-120
5. Covered interval - probably shale.	6	87-93
Middle calcarenite: 13 feet measured		
4. Limestone - buff to gray-brown, microcrystalline, thick, poorly bedded. Minor	13	74-87

	Description	Unit Thickness	Feet Above Base
	beds of finely allochemical, bioclastic fine grained limestone. Sparse dark chert nodules. At 86, light gray-brown, very homogeneous microcrystalline; contains abundant rod-like masses of sparry calcite; at 74.5, medium gray, spiculitic, finely allochemical, microcrystalline limestone.		
	Lower Marble Falls member: 74 feet measured		
3.	Limestone - dark gray-black microcrystalline, finely allochemical. Bedding irregular, 6 inches to 1 foot. Thin black chert layer at top of several beds.	10	64-74
2.	Limestone - medium gray-black, very homogeneous, microcrystalline. Bedding thick, 1 to 1.5 foot bed at 61; upper 1.5 feet thinbedded, contain many small brachiopods.	11.5	52.5-64.0
1.	Limestone - gray-black to blue-black, very homogeneous, microcrystalline. Bedding uneven, nodular, rough. Abundant black chert nodules and thin beds. Both limestone and chert jointed; joints filled with white chert.	52.5	0-52.5
	Base of section is at a fault, but must be very near the Barnett.		

LEONARD TANK SECTION (LT)

This section is approximately 7000 feet airline distance south by southeast from the Leonard Ranch headquarters. It may be reached by proceeding south from the ranch headquarters on a small road to a large earthen tank about 50 feet west of the road. The section is exposed along the western end of the tank; approximately 100 feet due west of the south end of the tank dam, and contains Chappel and 35 feet of Barnett.

Description	Unit Thickness	Feet Above Base
BARNETT FORMATION: 34. 66 feet measured		
4. Limestone - dark gray to gray-brown, microcrystalline, glauconitic; contains abundant crinoid columnals, fish bones, and teeth, ostracodes, and conodonts. Olive-brown shale partings thin, rare.	8	27-35
LT 35, Polygnathodella cf. P. ouachitensis Streptognathodus cf. S. elegantulus		
3. Limestone and shale - light yellow-brown to buff, microcrystalline, phosphatic limestone with minor olive-brown shale partings. Contains discoidal and ovoid pellets, goniatite fragments, pelecypods.	9	18-27
LT 27, Gnathodus bilineatus		
2. Shale - light brown, red, gray, and green; dark brown, silty microcrystalline limestone beds and concretions abundant.	18	0. 33-18. 0
LT 12, Gnathodus bilineatus		
LT 9, Gnathodus bilineatus Gnathodus commutatus		

Description	Unit Thickness	Feet Above Base
LT 5, Gnathodus bilineatus Gnathodus commutatus Gnathodus texanus		
CHAPPEL FORMATION: 0.33 foot measured		
1. Limestone - medium to light gray, microcrystalline and fine grained; contains quartz sand grains, crinoid columnals, limonite, conodonts. Gnathodus mosquensis Gnathodus macrolobus Polygnathus communis Polygnathus granulosa Pseudopolygnathus bicornis Pseudopolygnathus stricta Spathognathodus tridentatus	0.33	0.0-0.33

PECAN GROVE CREEK SECTION (PGC)

This section is located 4500 feet airline distance south by southeast of the Leonard Ranch headquarters. It may be reached by proceeding southeast from the ranch headquarters 0.2 mile on the Ellis Crossing road to a junction with a small road that parallels the San Saba River, 0.7 mile south on this road to the base of several hills where Pecan Grove Creek crosses the road.

The section is a composite with the Barnett, PGC(B), measured 1500 feet due west of the road, and in the bed of the creek. The lower 78 feet were measured 300 feet due west of the road, and up the north bank and slope. The upper 57 feet were measured along the road just north of Pecan Grove Creek in a small tributary.

Description	Unit Thickness	Feet Above Base
SMITHWICK FORMATION: 15 feet measured		
12. Shale with limestone interbeds - bright yellow-brown and olive-gray microcrystalline limestone. At 135 feet, pelmicrite 8 to 12 inches thick, broadly lenticular. At 125 feet, pelmicrite weathers to small nodular lumps, contains abundant pyrite, rare quartz sand grains. Shale olive-gray, badly weathered.	15	120-135
MARBLE FALLS FORMATION: 120 feet measured		
Upper Marble Falls member: 51 feet measured		
Upper calcarenite: 23 feet measured		
11. Fine bioclastic limestone - light to medium gray, microcrystalline, very finely allochemical. Abundant dark gray and blue-black	23	97-120

Description	Unit Thickness	Feet Above Base
chert nodules and thin beds. Bedding thin, obscure, undulose. Chert relatively unfossiliferous, but containing sponge spicules. At 110, intramicrite.		
Upper spiculite: 28 feet measured		
10. Silty limestone - light gray-brown, microcrystalline, silty, contains coarse grains of black organic matter. Bedding thin, 1 to 2 inches. At 95, 92, 91, intramicrite. Sponge spicules abundant on weathered surfaces. Shale interval from 92 to 94 feet.	12	85-97
9. Bioclastic conglomeratic limestone - algal intrasparrudite, medium gray-brown to red-brown, fine grained, allochemical, contains rounded dark limestone pebbles and much fossil debris. This is a single bed.	3	82-85
OFFSET to bed of Pecan Grove Creek 300 feet west of road. A small fault is at the base of the above unit, with estimated displacement of 5 feet.		
8. Limestone - light yellow-brown to gray-brown microcrystalline. Beds 1 to 2 feet thick in upper portions, thinning downward. Entire interval contains sponge spicules, is strongly limonitic. At 75, brachiopod biosparrudite.	8	69-77
Middle Marble Falls member: 67 feet measured		
Middle shale: 67 feet measured		
7. Shale and limestone - shale olive-gray, interbedded with thin, silty medium brown limestone beds in upper 10 feet. At 65, intrasparite.	67	2-69
Lower Marble Falls member: 2 feet measured		

Description	Unit Thickness	Feet Above Base
6. Black limestone and chert - medium gray to black, microcrystalline. Black chert nodules small, rare. Bedding thin, 1 to 2 inches, obscure. Limestone contains rare grains of glauconite and pyrite. At 1 foot, microsparite. Base not exposed at this locality, but other outcrops within 100 feet indicate thickness not in excess of 2 feet.	2	0-2
BARNETT FORMATION: 20 feet measured		
5. Phosphatic glauconitic limestone - biomicrite, medium gray, microcrystalline. Bedding thin, obscure, undulose, 8 to 10 inches thick in lower 2 feet, thinning upward. Glauconite abundant with rare quartz sand grains, phosphate pellets, many crinoid columnals, brachiopods, ostracodes and conodonts. Large ammonoids exposed on weathered surfaces. PGC 20, *Cavusgnathus cristata* *Polygnathodella* cf. *P. ouachitensis* PGC 19.5, *Cavusgnathus cristata* *Polygnathodella* cf. *P. ouachitensis* *Streptognathodus* cf. *S. elegantulus*	4	16-20
4. Limestone - micrite, black to medium gray microcrystalline. Banded and wavy, showing contorted effect of slumping. Fossils rare, only an occasional crinoid columnal.	0.5	15.5-16
3. Glauconitic brachiopod limestone - biomicrite, medium gray-brown, microcrystalline, glauconitic. Bedding distinct, undulose. Contains many elongate hollow tubes 0.25 mm. in diameter, brachiopods, crinoid columnals, rare trilobites, fish teeth, quartz sand grains, and phosphatic shell material. PGC 15.5, *Gnathodus bilineatus* *Gnathodus commutatus*	0.7	14.8-15.5

Description	Unit Thickness	Feet Above Base
<u>Cavusgnathus</u> <u>cristata</u> <u>Polygnathodella</u> cf. <u>P</u>. <u>ouachitensis</u> <u>Marginifera</u> cf. <u>M</u>. <u>welleri</u> <u>Marginifera</u> <u>roemeri</u> <u>Avonia</u> cf. <u>A</u>. <u>blairi</u>		
2. Phosphatic limestone - biosparite, light gray-brown to buff, microcrystalline. Beds 3 to 6 inches thick, contain sand size grains of phosphatic pellets, goniatite fragments, gastropod steinkerns, inarticulate brachiopods, and small pelecypods. Lower 3 feet contains shale interbeds.	6.8	8-14.8
1. Shale - pastel shales of red, brown, gray, and green. Weathers to a light olive-brown color. Large dark brown silty petroliferous limestone concretions present. At 8, phosphatic biosparite.	8	0-8

POST OAK CREEK SECTION (POC)

This section is located 2000 feet airline distance west of Lemons Camp. Its base is near the south bank of the San Saba River slightly downstream from the mouth of Post Oak Creek. The section was measured moving northward across the San Saba River to a point on the north bank about 5 feet downstream from the mouth of the creek, north by northeast to the base of the bluff, up and over the bluff. From the top of the bluff the section was measured directly up the hill to 138 feet; from there it is offset to the bed of the creek, and continues upstream to the base of the Smithwick. The base of the section is thought to be within 10 feet of the top of the Barnett.

Description	Unit Thickness	Feet Above Base
MARBLE FALLS FORMATION: 228 feet measured		
Upper Marble Falls member: 104 feet measured		
Upper calcarenite: 12 feet measured		
13. Bioclastic limestone - light gray to light brown microcrystalline to fine grained. Bedding thin, undulose. Medium gray to dark gray chert nodules and thin beds common. At 228, foraminiferal biosparite; at 227, 4 inch bed of black bioclastic chert containing much fossil debris and many fusulinids; at 225, foraminiferal intrasparite containing many snail steinkerns; at 220, intramicrite; at 218, foraminiferal spiculitic biomicrite. Weathering produces an outer brown-red siliceous skin and exposes numerous silicified fossils.	13	215-228

Description	Unit Thickness	Feet Above Base
POC 225, Bellerophon sp. Idiognathodus cf. I. delicatus		
POC 223, Idiognathodus cf. I. delicatus		
Upper spiculite: 91 feet measured		
12. Spiculitic cherty limestone - light to dark gray, microcrystalline, allochemical and light yellow-gray silty, spiculitic. Bedding thin, uneven, alternating 4 or 5 feet of allochemical limestone with 1 foot of spiculitic limestone. Numerous gray to gray-brown chert nodules and lenses. At 209 and 208, spiculitic biomicrite; at 203, spiculitic intramicrite.	20	195-215
11. Spiculitic limestone - pale brown to dark gray-brown, silty microcrystalline. Beds 1 to 2 feet thick, even. At 190, 185, 184, 180, 175, spiculitic biomicrite. At 184 single bed 2 feet thick. Interval from 175 to 185 unevenly bedded, nodular. Many spicules exposed on weathered surfaces.	30	165-195
10. Limestone and shale - light brown to medium gray-brown microcrystalline. At 164, spiculitic biomicrite; at 155, foraminiferal algal biomicrite; at 150, spiculitic intrasparite; at 145, clayey micrite; at 138, 131, clayey microsparite. Bedding uneven, thinning downward from 2 feet at top to 1 or 2 inches. Shale interbeds 4 to 6 inches thick from 165 to 160, 142 to 130.	41	124-165
Middle Marble Falls member: 64 feet measured		
Middle shale: 32 feet measured		
9. Shale - yellow-brown, badly weathered with thin beds of yellow-brown shaly limestone in upper 5 feet.	32	92-124

	Description	Unit Thickness	Feet Above Base
	Middle calcarenite: 32 feet measured		
8.	Algal limestone - medium pinkish yellow-brown, sublithographic. Beds less than 1 inch thick, obscure. At 90 and 86, algal biomicrite or dismicrite. Fresh surfaces show many angular patches of clear sparry calcite. Upper surface nodular, lumpy, covered with cobbles. POC 92, _Chaetetes_ sp. _Naticopsis_ sp.	7	85-92
7.	Bioclastic limestone - light to medium gray-brown, allochemical, fine grained and microcrystalline. Bedding thin, obscure, undulose. Limestone contains many intraclasts, fusulinids, and much fossil debris. At 76, brachiopod, foraminiferal, mollusc, algal biomicrite; at 71, algal biosparite; at 70, algal intramicrite. Sparse dark gray chert nodules from 85 to 75. Many round cobbles, 2 to 4 inches in diameter, from 78 to 71.	19	66-85
6.	Bioclastic limestone - light to medium gray, fine grained and microcrystalline. Bedding thin, obscure, undulose. At 66, crinoid, algal intrasparrudite; at 60, foraminiferal, crinoid, algal intrasparrudite. This entire interval appears as a single bed. Cross beds dipping 20° E exposed on east side of bluff. Acetic acid residues contain many fish teeth and bone fragments.	6	60-66
5.	Covered interval	17	43-60
	Lower Marble Falls member: 43 feet measured		
4.	Dark cherty limestone - light to medium gray-brown, microcrystalline, weathers to dull blue-gray. Bedding even, 6 to 8 inches thick. At 40 feet, algal intramicrite; at	8	35-43

Description	Unit Thickness	Feet Above Base
37 feet, algal, foraminiferal biomicrite. Sparse dark gray chert nodules. From 37 to 43 feet, fine calcarenite containing fusulinids and small intraclasts.		
3. Black limestone with black shale interbeds - medium gray to black, microcrystalline. Beds 2 to 8 inches thick, uneven. Black hard, brittle shale from 30 to 35 feet. At 30, fossiliferous micrite. At 24, fine calcarenite containing angular intraclasts, spicules, fusulinids.	11	24-35
2. Black cherty limestone - dark gray to black, silty microcrystalline. Beds thin, 1 to 2 inches thick, undulose, with large amoeboid black chert nodules and nodular beds. At 24, foraminiferal, algal biomicrite; at 20, foraminiferal algal pelmicrite.	8	16-24
1. Black cherty limestone - dark blue-gray to black, microcrystalline, with abundant large black chert nodules and beds. At 9, spiculitic biomicrite; at 1, bioclastic chert. Both limestone and chert are extremely jointed; joints filled with white chert.	16	0-16

SLOAN RANCH SECTION (SR)

This section is located 1000 feet airline distance southwest from the Jack Sloan ranch house. It was measured up the slope in a northwest direction. The section contains 8 feet of Barnett and 118 feet of Marble Falls; it is very poorly exposed and was measured primarily for thickness of the units within the Marble Falls.

Description	Unit Thickness	Feet Above Base
MARBLE FALLS FORMATION: 118 feet measured		
Upper Marble Falls member: 51 feet measured		
Upper spiculite: 51 feet measured		
5. Dark cherty limestone - light gray-brown to red-brown microcrystalline. Chert float abundant. Bedding even, distinct, varying from 2 inches to 1 foot.	51	75-126
Middle Marble Falls member: 60 feet measured		
Middle shale: 43 feet measured		
4. Shale - covered recessive slope. At 50 feet, numerous large black concretions. At 32 feet, nodular lumps of sublithographic olive-gray limestone.	43	32-75
Middle calcarenite: 17 feet measured		
3. Limestone - light to medium gray sublithographic and microcrystalline. Bedding thin. Abundant streaks of sparry calcite but few identifiable intraclasts.	17	15-32
Lower Marble Falls member: 7 feet measured		
2. Dark cherty limestone - black to dark gray microcrystalline. Surface of slope covered with boulders and cobbles of black chert.	7	8-15

Description	Unit Thickness	Feet Above Base
Bedding not apparent.		
BARNETT FORMATION: 8 feet measured		
1. Shale? - recessive covered slope with black limestone and chert float. Fragments of light to dark brown petroliferous concretions abundant.	8	0-8
ELLENBURGER GROUP: not measured		

APPENDIX B

FOSSIL LOCALITIES

Isolated fossil collections were made away from measured sections. These localities are indicated on the geologic map (Plate 1, in pocket) and are listed according to the rock unit and location; the species recovered from each locality are also listed.

FOSSIL LOCALITIES

OD-1, Marble Falls formation - spiculitic limestone near top of Lower Marble Falls member, 3000 feet west by southwest of Maxwell Crossing, 100 feet south of road to Lemons Camp. The fossils were recovered from limestone in the bed of a very small creek and along the foot of the slope.

Chonetes cf. *C. choteauensis*
Heteralosia cf. *H. slocumi*
Marginifera cf. *M. welleri*
Marginifera roemeri
Neospirifer goreii
Productus parvus
Punctospirifer cf. *P. campestris*

OD-2, Marble Falls formation - Middle shale. Fossils from lower 10 feet of shale just west of springs at Lemons Camp.

Chonetes dominus
Composita ozarkana
Dictyoclostus cf. *D. welleri*
Spirifer cf. *S. opimus*
Spirifer cf. *S. rockymontanus*
Punctospirifer cf. *P. kentuckyensis*

OD-3, Smithwick formation - shale. Fossils are from banks and dam of Burr Tank, 4000 feet west of road intersection just west of Hackberry Mill.

Cumminsia aplata
Chonetes cf. *C. granulifer*
Straparolus savagei

OD-4, Marble Falls formation - Upper calcarenite, 1600 feet southwest of Burr Tank, about halfway up the hill.

Straparolus plummeri
Sphaerodoma sp.
Bellerophon sp.

OD-5, Chappel formation - 1200 feet east of Hackberry Mill, in a road cut at the base of a gentle slope.

Polygnathus communis
Siphonodella duplicata

OD-6, Chappel formation - 3200 feet northeast of Nell Sloan ranch house, at north end of small tank east of road.

Gnathodus macrolobus
Gnathodus mosquensis
Palmatolepis glaber
Palmatolepis superlobata
Polygnathus communis
Polygnathus nodocostata
Polygnathus symmetrica
Pseudopolygnathus fusiformis
Siphonodella duplicata
Solenodella lacerata
Spathognathodus tridentatus

OD-7, Marble Falls formation - Middle shale, 1800 feet northeast of Nell Sloan ranch house, 200 feet east of road in an old caliche pit.

Composita ovata
Composita ozarkana
Squamularia perplexa
Euphemites sp.
Orthonychia parva
Worthenia tabulata

OD-8, Marble Falls formation - Middle calcarenite, 1600 feet east by northeast of the base of Challenge Mill North section, in limestone along the small creek. Silicified corals are abundant at this locality, but were not identified.

OD-9, Marble Falls formation - Middle shale, black limestone concretions near base, 5000 feet west by southwest of Leonard Ranch headquarters in bed of small stream about 200 feet northwest of a fence line.

Chonetes dominus
Linoproductus sp.
Marginifera cf. M. welleri

OD-10, Smithwick formation - shale on banks of a small stream 300 feet northwest of Ellis Crossing.

Cumminsia aplata
Phaneroceras compressum

OD-11, Lower Marble Falls member - 1500 feet south of Leonard Tank, 50 feet southeast of road on east bank of small stream. Algal bioherms that are circular patches of microcrystalline limestone showing accretionary folding.

OD-12, Chappel formation - 3500 feet southwest of Leonard Tank, in the east bank of a small stream.

Bactrognathus excavata
Bactrognathus hamata
Bactrognathus scorpiodes
Gnathodus mosquensis
Gnathodus texanus
Polygnathus communis

OD-13, Marble Falls formation - Middle shale, 100 feet south of Leonard Tank in shale limestone on slope of Hill.

Chonetes dominus
Wellerella cf. W. osagensis

APPENDIX C

PETROGRAPHIC DESCRIPTIONS

Thin sections of limestone and chert were described using terminology of Folk (1957). Descriptions and thin sections are labeled according to section and footage above base of section. The section is indicated by initials; the footage is numbered.

The only sections painted and described petrographically were the Post Oak Creek section and the Pecan Grove Creek section.

PECAN GROVE CREEK SECTION (PGC)

SMITHWICK FORMATION

PGC 135 Pelmicrite - allochems 20%, sparry calcite 0%, micrite 80%. Allochems - sponge spicules 10%. Vague pellets, dark and round, 0.1 to 0.2 mm. and well rounded, but partly obliterated by recrystallization. Cubic grains and elongate rods of weathered pyrite are common.

PGC 125 Pelmicrite - allochems 30%, sparry calcite 0%, micrite 70%. Allochems - vague dark round pellets 20%, sponge spicules 10%. Rock is very homogeneous and contains rare fusulinids.

MARBLE FALLS FORMATION

Upper Marble Falls member

Upper calcarenite

PGC 110 Intramicrite - allochems 50%, sparry calcite 10%, micrite 40%. Allochems - micrite intraclasts, 0.1 to 0.3 mm., vague, angular to rounded. Algal tubes, fusulinids and spicules 10%.

Upper spiculite

PGC 95
92
91 Intramicrite - allochems 30%, sparry calcite 0%, micrite 70%. Allochems - micrite intraclasts 30%, vague, angular to rounded, 0.1 to 0.2 mm. Spicules and fusulinids rare.

PGC 85 Algal intrasparrudite - allochems 70%, sparry calcite 20%, micrite 10%. Allochems - biomicrite and micrite intraclasts 40%, 0.2 to 4.0 mm., angular to very well rounded. Algal fragments 20%. Bryozoa, coral, trilobite, crinoid fragments, and fusulinids 10%. This section is strongly recrystallized with partial silicification of fossils.

PGC 78 Biomicrite - allochems 20%, sparry calcite 0%, micrite 80%. Allochems - micrite intraclasts 10%, angular, 0.03 to 0.04 mm., Spicules 10%.

PGC 75 Brachiopod biosparrudite - allochems 60%, sparry calcite 30%, micrite 10%. Allochems - brachiopod fragments up to 8 mm. long, 50%. Ostracods, fusulinids and small vague intraclasts, 10%.

Middle Marble Falls member

Middle shale

PGC 65 Intrasparite - allochems 20%, sparry calcite 0%, micrite 80%. Allochems - micrite intraclasts 20%, angular to rounded, 0.2 to 0.3 mm. Rare spicules, and round chert grains and grains of translucent yellow-brown mineral thought to be collophane (bone fragment?).

PGC 59 Fossiliferous intrasparite - allochems 70%, sparry calcite 30%. Allochems - micrite intraclasts 60%, algal tubes and fusulinids 10%.

PGC 56 Fossiliferous micrite - allochems 20%, sparry calcite 0%, micrite 80%. Allochems - micrite particles 20%, vague, 0.01 to 0.02 mm. Abundant quadrate patches of sparry calcite thought to be recrystallized algal fragments.

Lower Marble Falls member

PGC 1 Microsparite - allochems 10%, sparry calcite 5%, micrite recrystallized to microspar 85%. Allochems - quadrate patches of sparry calcite thought to be recrystallized algal plates, and rare grains of glauconite and pyrite. Organic matter is extremely abundant, 1 to 5 microns, and finely disseminated.

BARNETT FORMATION

PGC(B) 20 Phosphatic glauconitic biomicrite - allochems 60%, sparry calcite 5%, micrite 35%. Allochems - brachiopod spines 35%, ostracods and crinoid fragments 10%, phosphate pellets and ooids 10%. Glauconite 5%. Abundant finely disseminated organic matter.

PGC(B) 19.5 Phosphatic glauconitic biomicrite - allochems 20%, micrite recrystallized to microspar 80%. Allochems - phosphatic pellets and ooids 10%, brachiopod spines 5%, glauconite 5%. Abundant finely disseminated organic matter.

PGC(B) 16 Slumped micrite - allochems 2%, sparry calcite 0%, micrite 98%. Allochems - crinoid columnals 2%. Swirled arrangement of organic matter and orientation of grains of calcite indicate soft sediment slumping.

PGC(B) 15.5 Glauconitic brachiopod biomicrite - allochems 50%, sparry calcite 0%, microspar 20%, micrite 30%. Allochems - brachiopod fragments 30%, trilobite and crinoid fragments 15%, glauconite 5%. Rare quartz sand grains, subround, average 0.5 mm.

PGC(B) 14.8 Phosphatic biosparite - allochems 30%, sparry calcite 0%, microspar 50%, micrite 20%. Allochems - phosphatic pellets of fusiform shape and ovoid shape, 10%. Phosphatic shell fillings or coatings of goniatitic ammonoids, gastropods, inarticulate brachiopods, 25%. Phosphatic ooids 5%. Cavities of larger fossils are filled with coarse sparry calcite.

PGC(B) 13 Phosphatic biosparite - allochems 20%, sparry calcite 0%, microspar 20%, micrite 60%. Allochems - same as PGC(B) 14.8.

PGC(B) 8 Phosphatic biosparite - allochems 5%, sparry calcite 0%, microspar 15%, micrite 80%. Allochems - same as PBC(B) 13.

POST OAK CREEK SECTION (POC)

MARBLE FALLS FORMATION

Upper Marble Falls member

Upper calcarenite

POC 228 Foraminiferal biosparite - allochems 80%, sparry calcite 15%, micrite 5%. Allochems - algal fragments 75%, fusulinids 5%. Abundant microcrystalline quartz.

POC 227 Bioclastic chert - texture resembles POC 228.

POC 225 Foraminiferal intrabiosparite - allochems 60%, sparry calcite 40%. Allochems - algal fragments 30%, rare fusulinids. Intraclasts 30%, composed of algal fragments in microcrystalline ooze, 0.3 to 1.0 mm. and extremely well rounded.

POC 220 Intramicrite - allochems 20%, sparry calcite 80%. Allochems - vague microcrystalline ooze, 0.1 to 0.02 mm. and rounded.

POC 218 Foraminiferal spiculitic biomicrite - allochems 30%, sparry calcite 60%, micrite 10%. Allochems - intraclasts 20%, angular, well sorted, 0.5 to 1.0 mm. and loosely packed.

Upper spiculite

POC 209 Spiculitic biomicrite - allochems 30%, sparry calcite 40%, micrite 30%. Allochems - calcareous and siliceous spicules 30%, abundant disseminated organic matter and random patches of microcrystalline quartz.

POC 208 Spiculitic intramicrite - allochems 50%, sparry calcite 30%, micrite 20%. Allochems - intraclasts 50%, algal fragments in ooze, 0.2 to 0.4 mm., well rounded, loosely packed.

POC 203 Spiculitic intramicrite - same as POC 208.

POC 190, 185, 184, 180, 175 Spiculitic biomicrite - allochems 40%, sparry calcite, 20%, micrite 40%. Allochems - intraclasts 5%, ooze, well sorted, 0.2 to 0.3 mm. Spicules and algal fragments 35%. Large amounts of microcrystalline quartz, few clay flakes.

POC 170 Spiculitic biomicrite - allochems 75%, micrite 25%. Allochems - sponge spicules 75%. Abundant microcrystalline quartz and clay flakes.

POC 164 Spiculitic biomicrite - allochems 10%, sparry calcite 70%, micrite 20%. Allochems - sponge spicules 10%. Numerous clay flakes and much organic matter. Strongly recrystallized to microspar.

POC 155 Foraminiferal algal biomicrite - allochems 70%, sparry calcite 20%, micrite 10%. Allochems - algal fragments 60%, random and loosely packed. Common clay flakes and abundant microcrystalline quartz. Strongly recrystallized.

POC 150 Spiculitic intrasparite - allochems 4%, sparry calcite 80%, micrite 16%. Allochems - intraclasts 4%, microcrystalline ooze, 0.1 to 0.2 millimeters. Rare grains of phosphate or glaucophane.

POC 145 Clayey micrite - allochems 2%, sparry calcite (microspar) 98%. Allochems - sponge spicules 2%. Abundant clay flakes.

POC 138 Clayey microsparite - allochems 0%, sparry calcite (microspar)
131 25%, micrite 75%.

Middle Marble Falls member

Middle calcarenite

POC 90 Algal biomicrite (dismicrite) - micrite 75%, sparry calcite 25%. Sparry calcite has angular characteristic of algal fragments. Slide shows a coral skeleton.

POC 86 Algal biomicrite (dismicrite) - micrite 65%, sparry calcite 35%. Sparry calcite angular and crescentic in outline.

POC 76 Brachiopod foraminiferal mollusc algal biomicrite - allochems 65%, micrite 30%, sparry calcite 5%. Allochems - fragments of brachiopods, pelecypods, gastropods, bryozoa, fusulinids, and algae. Algal fragments are round and hollow, 0.4 to 1 mm.

POC 71 Algal biosparite (spheroidal cobble) - allochems 75%, sparry calcite 15%, micrite 10%. Allochems - algal plates and fragments 50%, crinoid fragments 10%, foraminifera 5%. Algal fragments poorly sorted, 0.1 to 20 mm. Allochems show partial silicification.

POC 70 Algal intramicrite - allochems 80%, sparry calcite (microspar) 16%, micrite 4%. Allochems - algal and crinoid fragments 50%, dark micrite intraclasts 10%, rounded and well sorted, 0.6 to 0.1 mm.

POC 66 Crinoid and algal intrasparrudite - allochems 75%, sparry calcite 25%. Allochems - biomicrite intraclasts 60%, angular and rounded, 0.5 to 2 mm., showing partial recrystallization. Algal and crinoid fragments 10%. Rare ooids and phosphate pellets.

POC 60 Foraminiferal crinoid algal intrasparrudite - allochems 85%, sparry calcite 15%. Allochems - intraclasts biomicrite 50%, angular and rounded, 0.5 to 2.0 mm., poorly sorted. Algal tubes, fusulinids, crinoid fragments, corals 35%, showing partial recrystallization.

Lower Marble Falls member

POC 40 Algal biomicrite - allochems 85%, sparry calcite 10%, micrite 5%. Allochems - algal fragments 80%, sponge spicules, fusulinids 5%. Strongly recrystallized to microspar.

POC 37 Algal foraminiferal biomicrite - allochems 80%, microspar 15%, micrite 0%, sparry calcite 5%. Allochems - algal fragments 70%, angular, 0.07 to 0.08 mm., well sorted. Foraminifera 10%, Rare ooids and phosphate grains.

POC 30 Fossiliferous micrite - allochems 8%, microspar 92%. Allochems - brachiopod and bryozoa fragments, sponge spicules 8%, showing partial silicification.

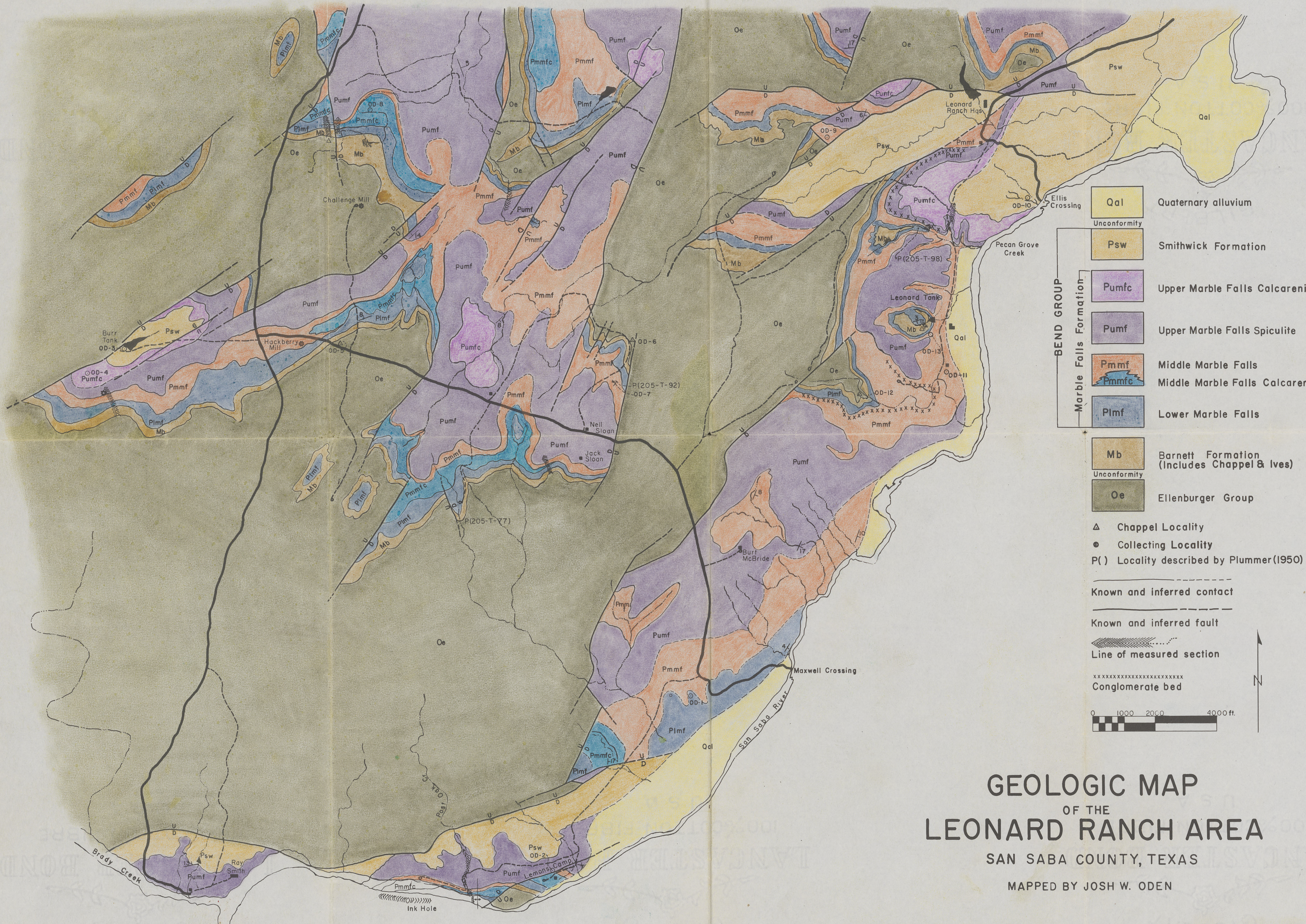
POC 24 Foraminiferal algal biomicrite - allochems 25%, microspar 75%. Allochems - algal and crinoid fragments 25%, loosely packed and well sorted. Rare fusulinids, pyrite, phosphate grains and calcareous ooids.

POC 20 Foraminiferal algal biopelmicrite - allochems 50%, microspar 30%, micrite 20%. Allochems - crinoid fragments 20%, sponge spicules 30%, showing intensive recrystallization. Rare phosphatic ooids.

POC 9 Spiculitic biomicrite - allochems 70%, microspar 30%. Allochems - sponge spicules 70%, partially obliterated by recrystallization. Much organic matter, 3 to 10 microns.

POC 1 Bioclastic chert - contains many spicules, partly destroyed foraminifera and unsilicified crinoid fragments.

The vita has been removed from the digitized version of this document.



Qal	Quaternary alluvium	Quaternary
Unconformity		
Psw	Smithwick Formation	
Pumfc	Upper Marble Falls Calcarenite	
Pumf	Upper Marble Falls Spiculite	Pennsylvanian
Pmmf	Middle Marble Falls	
Pmmfc	Middle Marble Falls Calcarenite	
Plmf	Lower Marble Falls	
Mb	Barnett Formation (Includes Chappel & Ives)	Mississippian
Unconformity		
Oe	Ellenburger Group	Ordovician

BEND GROUP

Marble Falls Formation

△ Chappel Locality

● Collecting Locality

P( ) Locality described by Plummer (1950)

Known and inferred contact

Known and inferred fault

Line of measured section

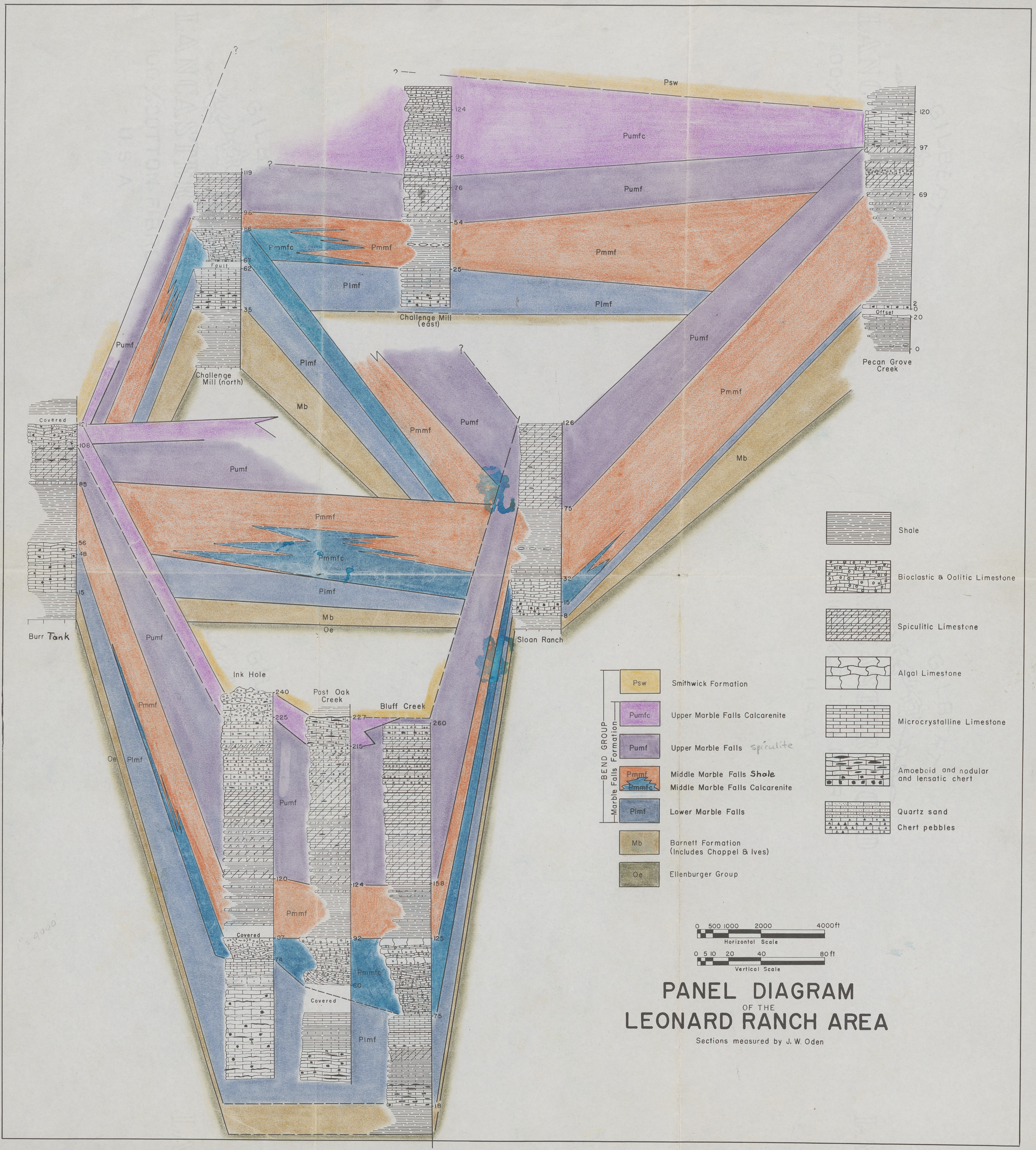
Conglomerate bed

0 1000 2000 4000 ft.

N

GEOLOGIC MAP
OF THE
LEONARD RANCH AREA
SAN SABA COUNTY, TEXAS

MAPPED BY JOSH W. ODEN



PANEL DIAGRAM
OF THE
LEONARD RANCH AREA

Sections measured by J. W. Oden